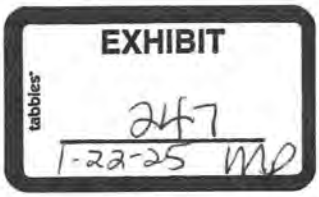
# PLAINTIFFS' SUMMARY JUDGMENT OPPOSITION

# EXHIBIT A-21

TOSHIBA

KENTARO TAKAGI
CHAIRMAN & CEO

October 31, 2024




VIA E-MAIL AND OVERNIGHT COURIER
Srikanth Maddipati
Vice President, Electric Supply
Consumers Energy Company
One Energy Plaza
Jackson, MI 49201-2357

RE: Purported Notice with Respect to Termination of the Ludington Pumped Storage Plant EPC Contract dated October 15, 2010, as amended (the "Contract")

Dear Mr. Maddipati:

This letter responds to your letter dated October 22, 2024 that purports to provide Toshiba America Energy Systems Corporation ("TAES") with "notice with respect to termination of the Contract for Major Default as described in GC7(b)(ii) of Section II of the Contract."

At the outset, we dispute your stated belief that "notice is not required"; if in fact the Owner intends to initiate the process for termination under GC7(b)(ii), that provision plainly requires written notice. Notably, in the pending court action referenced in your letter, the Owner expressly admitted that it had not terminated the Contract: "Consumers Energy and DTE admit that the Contract provides a mechanism for termination and that they have not terminated the Contract pursuant to that mechanism." No. 22-cv-10847, ECF No. 20 PageID.431 ¶ 24 (filed July 15, 2022).

For the avoidance of doubt, TAES does not waive or excuse the Owner's obligations under the Contract in any way.

We also dispute that your letter is sufficient written notice of any "Major Default" you are alleging. Your general reference to prior communications and your complaint in the pending court action is not sufficient, particularly when your allegations of breach have evolved considerably over time. For example, without limitation, while the Owner has alleged that the discharge rings on all Units needed to be replaced, we now understand the Owner to assert that only the discharge rings on Units 2 and 4 need to be replaced. For further example, without limitation, your letter refers to "the Unit 5 runner defect," while the Owner's proposed expert in the pending court action asserts that the Owner already has undertaken "Unit 5 Runner Crack Repair." Proposed Expert Report of Michael P. Emmert (dated June 14, 2024) at Ex. C.1. As a further illustration, the Owner's complaint in the pending court action alleges that replacing a DRE in a Unit "will cost at least tens of million dollars," ECF No. 1 ¶ 111 (filed April 20, 2022), but the Owner has since inflated that allegation by an order of magnitude. GC7(b)(ii) is a cure provision and it requires the Owner to specify any alleged "Major Default" that the Owner believes to require cure.

Toshiba America Energy Systems Corporation
6623 W. Washington Street, West Allis, Wisconsin 53214
Phone: (414) 475-3889
www.toshiba.com/taes

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Among other important missing context, your letter fails to account for the fact that, pursuant to the Contract, the Owner provided notice of "Unit Final Acceptance" after the requisite hours of Extended Commercial Operation Test ("ECOT") under the Contract for Unit 5 on December 18, 2017 and for Unit 2 and Unit 4 on December 21, 2019, meaning for each applicable Unit that "the Owner deems the Work of this Unit to be complete and the Owner can now conduct routine commercial operation of the Unit." Conformed Contract Specification, Part Two – Technical Specifications 1140-003 § 5.8.6. The Owner has admitted, for example: "Unit [2]'s major overhaul was completed and turned to commercial operation test on March 12, 2015. The performance test carried out verified that Unit [2] has successfully achieved its target performance." *Hydro Review* (Nov. 2016).

Similarly, your letter ignores that the Owner provided notice of "Unit Interim Acceptance" under the Contract for Unit 6 on May 13, 2018, Unit 1 on June 26, 2019, and Unit 3 on April 2, 2022, and those three Units each successfully completed its ECOT under the Contract (respectively, on October 24, 2018; September 19, 2019; and July 9, 2019), yet the Owner unreasonably has withheld Unit Final Acceptance for each of these three Units.

Your letter also fails to address that to date the Owner has continued to operate each of the six Units commercially at least since the successful completion of ECOT for each Unit. Furthermore, the Owner has admitted, for example: "In the case of pump operation, the pump discharge of the new runner increased about 15% compared with the original at all head ranges." *Hydro Review* (Nov. 2016). TAES achieved such improved performance of the Units notwithstanding the parties' express agreement in the Contract that the effectiveness of the overhaul is limited by the fact that "by the start of the Work, the Plant will have been in operation for 40 years." Conformed Contract Specification, Part Two – Technical Specifications 1140-003 § 3.0. Beyond ignoring the successful commercial operation of the Units for many years—and the improved performance and capacity of the Units after TAES's overhaul—your letter ignores that the parties expressly agreed that "the Owner's expectation" of a thirty (30) year service life "is not intended to expand the length of the Warranty Period . . . ." Conformed Contract Specification, Part Two – Technical Specifications 1140-003 § 1.7.1.

Your letter likewise ignores that despite the Owner demanding performance from both TAES and Toshiba Corporation ("Toshiba") under the Contract and the accompanying Parent Guaranty, including after the Owner commenced the pending court action, the Owner unreasonably interfered with the ability of TAES and Toshiba to perform any purported outstanding obligations under the Contract or the Parent Guaranty, including without limitation by severely restricting the access of any TAES or Toshiba personnel to the Ludington Plant. Obviously, TAES and Toshiba cannot be faulted for any problems arising after being shut out of the Plant, especially when those problems are attributable to the conduct of the Owners (or third parties), such as improper usage, lack of proper maintenance, or other misfeasance or nonfeasance.

In short, your letter obscures the reality that TAES dutifully performed its obligations under the Contract and continued to perform its obligations even after the Owner breached by failing to make its contractually obligated payments to TAES. And, far from your blatant mischaracterization that TAES "abandoned" the project, the Owner wrongfully shut TAES out. It is the height of hypocrisy for the Owner to shut out TAES and then complain about TAES's absence and invoke a cry of "abandonment." The Owner has

Toshiba America Energy Systems Corporation
6623 W. Washington Street, West Allis, Wisconsin 53214
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been profiting for years based on TAES's work, but nonetheless asserts contrived and opportunistic claims in an effort to extract additional ill-gotten gains. TAES will not tolerate such greed at its expense.

The points above are exemplary, without prejudice, and TAES reserves all rights, including without limitation regarding the actions and inactions of the Owner and the material omissions and selective references in your letter.

TAES disputes that the Owner has any valid basis to terminate the Contract for a Major Default pursuant to GC7(b)(i) of Section II of the Contract. Notwithstanding such dispute, without limitation as to other potential responses, expressly disputing any liability or outstanding obligation to the Owner under the Contract, and otherwise reserving all rights, TAES provides the Owner a corrective action and recovery plan as contemplated in GC7(b)(ii) of Section II of the Contract (enclosed). This plan is communicated in good faith for a reasonable and effective repair without prejudice to TAES's rights to contest any claim for liability or damages by the Owner under the Contract. For example, without limitation, the parties' contractual obligations do not provide for any stainless steel overlay on the discharge rings in any of the Units, while the parties did agree to a stainless steel overlay on the cooling water inlet to the stationary wearing ring. Contract Technical Specification Section ME-11450.4 §§ 3.16.1-2. TAES's performance has been governed by the parties' express agreement that "the Owner intends to have significant involvement in all aspects of the design, engineering, manufacturing, procurement, examination, inspections, tests, and installation of the various components, items of equipment, materials, and services to be provided by the Contractor." Conformed Contract Specification, Part Two – Technical Specifications 1140-003 §3.0.

For further example, without limitation, the parties expressly agreed to a "cavitation guarantee" for the turbine runners in each of the Units but not for any other component. Conformed Contract Specification, Part Two – Technical Specifications § 3.3.1, Pump-Turbine Runner Cavitation Guarantee, ME-11450.2-4. As the Owner has admitted, TAES's work successfully resolved longstanding cavitation problems that the Owner encountered with the prior turbine runners: "Particularly in the past few years, numerous issues have required increased maintenance, resulting in scheduled outages to perform routine maintenance every two years. The bulk of the maintenance activity during this time was cavitation repair on the pump-turbine runners. . . . The pump-turbines for the Ludington plant were redesigned by Toshiba using the latest technology to improve efficiency and pump cavitation performance and increase turbine output and pump discharge. . . . Additionally, by using a nine-blade runner, load was reduced on each blade, leading to less cavitation." *Hydro Review* (Nov. 2016). Illustrating the conspicuity and mutuality of the parties' agreement on a "cavitation guarantee" solely on the turbine runners, the Owner's expert in the pending court action discusses the cavitation problems that the Owner encountered on the Unit discharge rings for many years prior to entering the Contract: "The previously described cavitation erosion damage to the DR in Unit 2 and Unit 4 is not the first occurrence of cavitation erosion damage on the DRs of the units at the Ludington Plant. Turbine repair documents from 1992 and 1994 provide instructions for weld repair of cavitation and corrosion pitting on the DRs of the six units. Some of the revisions in documents date back to 1987." Proposed Expert Report of Joseph C. Tucker, Ph.D., P.E. (dated June 14, 2024) at 99-100 (footnote citations omitted).

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The communication of the enclosed corrective action and recovery plan, furthermore, is without prejudice to TAES's rights to assert that the Owner materially breached the Contract long before filing the pending court action, including without limitation due to longstanding nonpayment for work completed pursuant to the Contract and that such amounts owed by the Owner more than offset the value of any purported liability, damages, or outstanding obligation of TAES. In particular, the Owner owes: (i) $521,225.00 for Invoice 105926 tendered on April 14, 2020; (ii) $3,518,839.00 for the Unit 6 retention amount since that Unit successfully completed its ECOT under the Contract on October 24, 2018; (iii) $8,893,086.00 for the Unit 1 retention amount since that Unit successfully completed its ECOT under the Contract on September 19, 2019; and (iv) $2,697,738.00 for the Owner's failure to issue Change Order 11 for the work TAES performed in excess of $1,000,000.00 under Change Order 10 (executed on January 17, 2018). These amounts owed by Owner totaled at least $15,630,888.00 as of the counterclaims filed in the above-referenced action on June 24, 2022, exclusive of pre- and post-judgment interest and attorneys' fees and costs that may be due under Michigan law.

Please contact me in writing concerning next steps for the enclosed corrective action and recovery plan. TAES stands ready to commence implementation of the plan. If for some reason the Owner does not find the plan acceptable, TAES stands ready to engage in the dispute-resolution process set forth in GC9 of Section II of the Contract.

Sincerely,

K. Takagi

Ken Takagi
Chairman & Chief Executive Officer
TAES

Enclosure
Corrective Action and Recovery Plan

Toshiba America Energy Systems Corporation
6623 W. Washington Street, West Allis, Wisconsin 53214
Phone: (414) 475-3889
www.toshiba.com/taes

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# 技術連絡書 ENGINEERING COMMUNICATION SHEET

ECS K2022H0456-a



宛先 TO

Consumers Energy Company & DTE Energy Company

| | | |
|---|---|---|
| ☐ 御検討用 FOR REVIEW<br>☐ 御確認用 FOR CONFIRMATION<br>☐ 御参考用 FOR INFORMATION<br>☐ 指示用 FOR NOTICE | ☐ 依頼 REQUEST<br>☐ 回答 REPLY<br>（説明:該当は■ 非該当は□） | 回答希望日 REPLY DEAD LINE<br>■ 回答不要 NO REPLY REQUIRED |
| プラント PROJECT<br>XULU | 機器名 EQ/SYS. | 製造／見積番号 JOB/QUOT.NO. |

題 目 SUBJECT

Technical Proposal for Discharge Ring Extension



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|---|---|---|---|---|
| 社内配付先 DISTRIBUTION | | | 発行部課名 ISSUED BY<br>水力・発電機部<br>水力機器基本設計グループ<br>HYDRAULIC TURBINE & GENERATOR DEPT<br>HYDRAULIC TURBINE ENGINEERING GROUP | 承 認 APPROVED BY<br>調 査 REVIEWED BY<br>担 当 PREPARED BY<br>K. Hamaguchi<br>Oct. 28. 2024 |

東芝エネルギーシステムズ株式会社 京浜事業所
TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORPORATION Keihin Product Operations

**Contents**

## 1 Structure of DRE

One of the main objectives of this overhaul was to increase the runner output and improve the cavitation performance by replacing the runner. In particular, the cavitation erosion of existing OEM runner was so severe that it was necessary for CEC to perform large-scale welding repairs to the runner blades every few years of operation. Based on Competitive Model Test Results, Toshiba proposed taller runner to achieve these performance objectives. The taller runner necessitated modifications to the discharge ring whereby a section of the existing discharge ring including runner parking ledge was removed and a new discharge ring extension (DRE) was installed, see Appendix 1-1, pages 1 & 2.Toshiba's replacement runner and DRE modification design concepts were approved by CEC and incorporated into the Conformed Contract Specification (Part Two, Technical Specification, ME-11450.1 – Competitive Model Test Results (Toshiba Model Test Report, Document No. ERP-35651) and ME-11450.4 – Design and Manufacture of Pump Turbine Runners, Section 3.16.4 (Discharge Ring Extension)) prior to Contract Award.

Overall, Toshiba replacement runners have demonstrated significant improvements in cavitation performance and unit output and pumping capacity (exceeding 360 MW guarantee and approaching 400 MW (CEC's net demonstrated capacity results)).

Post-refurbishment operational results have necessitated two modifications to Toshiba's DRE design. First, large shaft vibrations were experienced on 1st (U2) and 2nd (U4) units during high-head pump operation caused by runner self-excited vibration. Toshiba proposed to suppress this shaft vibration by utilization of existing air injection system and CEC approved and adopted this method for U2 and U4. Beginning with 3rd (U5) unit, Toshiba proposed and CEC approved addition of a lower hydraulic seal to eliminate this runner self-excited vibration. This lower hydraulic seal proved effective and was adopted on remaining units. Second, original DRE design included qty. 4 pockets to measure runner to wearing ring gap. Several of the U2 and U4 pocket covers came loose during operation. Toshiba proposed and CEC approved removal of U2 and U4 pocket covers, welding of U5 pocket covers during DRE shop fabrication, and elimination of pockets on remaining units.

CEC rejected 6th (U3) DRE due to cracking in parking ledge corner during installation. Toshiba proposed and CEC approved material and structural changes for a replacement U3 DRE that was manufactured and installed.

Reference Appendix 1.1, pages 3 – 6 for DRE structural differences between units as described above.

## 2 Requirements for DRE

Basic functions required for the discharge ring in the hydropower industry include:

- Water sealing function
- Runner sealing function (reduction of water leakage around runner)
- Runner support (parking ledge) during disassembly/reassembly

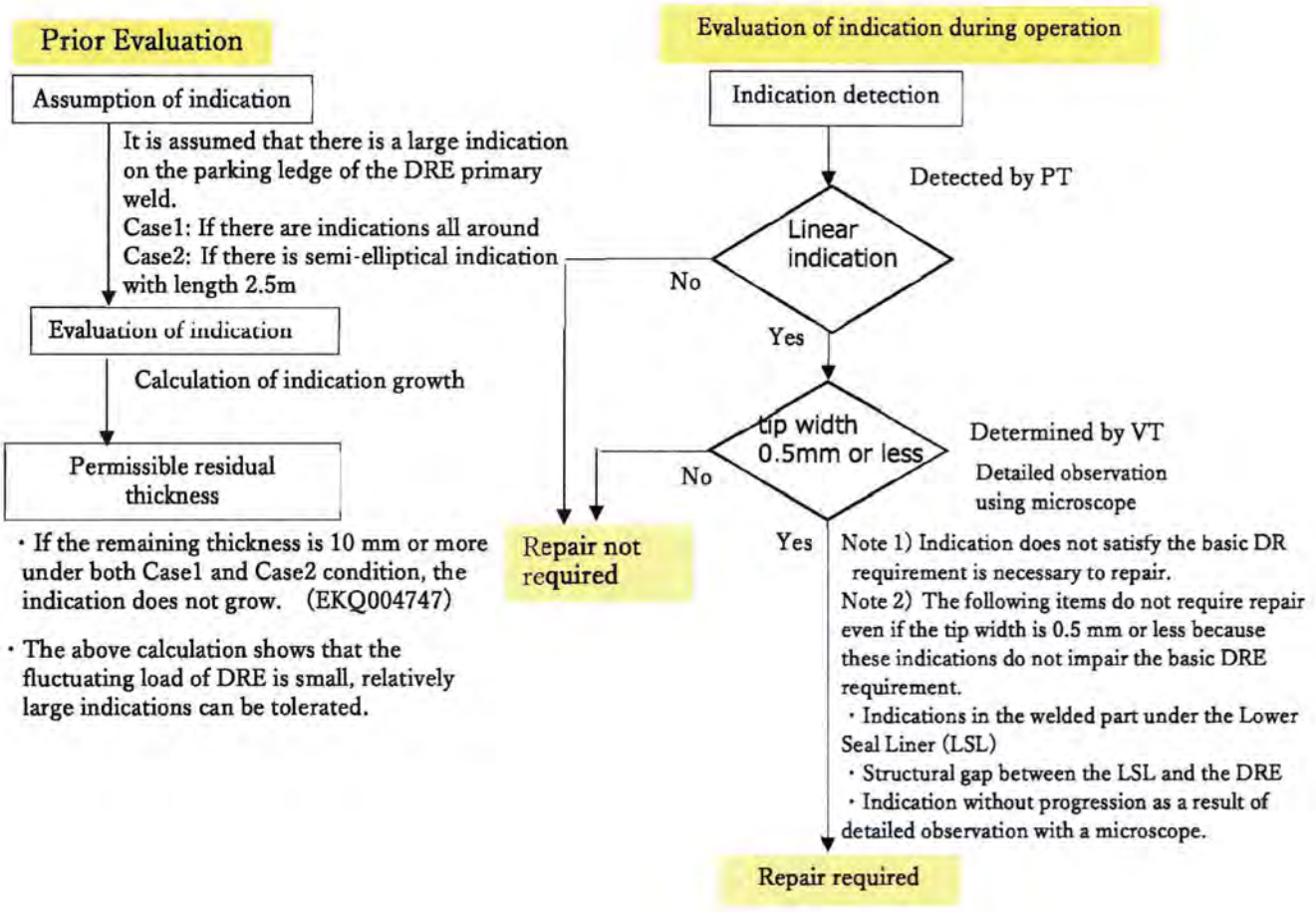
Additionally, contract service life requirements specify periodicity of 3 years between planned preventative maintenance inspections.

## 3 Current DRE Situation

### 3.1 Inspection Acceptance Criteria During Operation

During operation, there is the possibility for DRE surface wear and tear due to collision with foreign objects, like ice and debris, so in June 2020 we stipulated DRE inspection acceptance criteria (ECSK2020H0203). The concepts and benefits of utilizing these criteria include (See Appendix 3-1):

- Repeatable, established criteria based on allowable thickness and indication size.
- Evaluations according to established criteria does not require calculations.
- NDE inspections (PT and visual) result in no damage to DRE.
- Criteria avoids unnecessary repairs.



Since the fluctuating load acting on the DRE during operation is small, relatively large indications can be tolerated. Therefore, it is not necessary to repair indications that are clearly not progressing.

Following 2019 CEC NDE inspections and repairs of U2, U4 & U5 DREs it was agreed that Toshiba should develop DRE warranty inspection acceptance criteria for future inspections. Toshiba developed DRE inspection criteria (ECSK2020H0203) in consideration of practical field application. Toshiba has successfully applied ECSK2020H0203 criteria during DRE NDE inspections performed in 2020, 2021, and 2022 and completed weld repairs when necessary. To date, follow-up NDE inspections of repaired areas indicate no repair rework is required.

Additional design detail and technical justification for ECSK2020H0203 criteria can be found in Appendix 3-1.

### 3.2 Condition of Each DRE (PT indications)

Summaries of NDE dye penetrant test (PT) indication types and inspection results by unit follow –

**Indications Types –**

**Rounded indications**

a) Missing inclusion from base material, Appendix 3-2, Samples A-1 & A-2
b) Unmelted portion of weld (insufficient penetration), Appendix 3-2, Sample A-3
c) Fine pinholes in welds, Appendix 3-2, Sample A-4
d) Fine blow holes in welds, Appendix 3-2, Sample A-5
e) Insufficient finish of weld bead, Appendix 3-2, Sample A-6

**Linear indications**

f) Missing inclusion from base material, Appendix 3-2, Samples B-1, B-2 & B-3
g) Base metal corrosion (upper draft tube), Appendix 3-2, Sample B-4
h) Unmelted portion of weld (insufficient penetration), Appendix 3-2, Sample B-5
i) Insufficient finish of weld bead, Appendix 3-2, Sample B-6
j) Surface burrs on base material, Appendix 3-2. Sample B-7
k) Unmelted part of the weld under the lower seal liner (insufficient penetration), Appendix 3-2, Sample C-1
l) Visible gap between Lower seal liner and DRE, Appendix 3-2, Samples C-2, C-3 & C-4
m) No obvious flaws, Appendix 3-2, Samples D-1, D-2 & D-3

**History by Unit –**

**1st (Unit 2)**

U2 DRE NDE inspections were performed in September 2019. A crack of 38 inches in length was observed in the parking ledge corner. The presumed root cause for this crack can be explained as follows. The DRE had a pre-existing internal weld defect from the factory welding stage. Some internal factory weld defects could not be detected because the NDE applied to this weld was not 100%, but MT 100% and UT 20%. The DRE top and bottom were welded to existing draft tube during field installation, resulting in residual stress in this area. If a large crack existed inside the factory weld, it may have propagated to the surface (back surface or front surface). As a result, internal defects propagated close to the surface. After the start of unit operation, self-excited vibration of the runner occurred, and although the residual stress value was small in the DRE, a larger than usual cyclic load occurred. Since the remaining thickness around the internal defect was thin, the crack penetrated to the surface. Based on this root cause crack evaluation, weld repairs

were completed in October 2019. Subsequent NDE inspection of this weld repair have been acceptable (no crack re-occurrence).

U2 DRE NDE inspections were performed October 2020 & June 2021 and repairs were performed based on ECSK2020H0203 criteria.

During April 2022 MTB outage U2 DRE NDE inspections were performed and water leakage at the seal weld of a grout hole plug was observed by microscope. This grout hole plug seal weld was repaired. No additional repairs were required per ECSK2020H0203 criteria and microscope inspection.

**2nd (Unit 4)**

U4 DRE NDE inspections were performed in September 2019 one indication at SE pocket frame weld line was repaired.

U4 DRE NDE inspections were performed during May 2021 pond outage and repairs were performed according to ECSK2020H0203 criteria.

U4 DRE NDE inspections were performed during May 2022 MTB outage and Toshiba observed no progression of previously identified indications. CEC's NDE report was received only at the end of the outage after the departure of Toshiba engineers.

**3rd (Unit 5)**

U5 DRE NDE inspections were performed in October 2019 and repairs were performed according to ECSK2019H0257.

PT was held in October 2020. (ECSK2020H0360 and ECSK2021H0143 for treatment)
Some places were repaired (only cracked), but some of them were decided to be repaired at the next outage due to time limitation of Spring outage in 2022.
PT was held in May 2021. Repaired according to ECSK2020H0203 and ECSK2021H0198.

U5 DRE NDE inspections were performed in May 2022 and revealed small indications of water leakage in the area of pocket cover factory welds. The presumed root cause is that final field machining of DRE resulted in material removal of pocket cover factory weld thickness resulting in water leakage. No other indications from May 2022 U5 NDE inspection required repair based on ECSK2020H0203 criteria. CEC postponed U5 DRE pocket cover weld repairs until October 2022 at which time Toshiba successfully completed those repairs. U5 DRE NDE inspections were performed

in October 2022 and no other repairs were required per ECSK2020H0203 criteria.

**4th (Unit 6)**

U6 DRE NDE inspections were performed October 2020 and repairs were performed based on ECSK2020H0203 criteria. U6 DRE NDE inspections were performed June 2021 and June 2022 and no additional repairs were required per ECSK2020H0203 criteria.

**5th (Unit 1)**

U1 DRE NDE inspections were performed during the May 2021 pond outage and repairs were performed based on ECSK2020H0203 criteria. U1 DRE was inspected during Spring 2022 MTB outage and no additional repairs were required per ECSK2020H0203 criteria.

**6th (Unit 3)**

Unit was returned to service April 2022. To date, no post operation NDE inspections have been performed.

To summarize unit by unit DRE inspection and repair history detailed above, repaired indications have not required rework.

### 3.3 Corrosion Situation by Unit

Beginning in 2019 NDE inspection were started on Toshiba refurbished units which had been returned to service. A summary of those inspection results follows. Additional detail is provided in Appendix 3-4.

**1st (Unit 2)**

An October 2019 inspection found corrosion in the original carbon steel portion of discharge ring immediately below the new Toshiba wearing ring (legacy parking ledge area).
TAES study results: maximum depth 0.3" (7.6mm).

During the May 2021 pond outage Toshiba applied paint coating (Sabi-Shut) in an attempt to slow the progression of corrosion in legacy parking ledge area.

A follow-up inspection was performed during the April 2022 MTB outage. Maximum corrosion depth of 19 mm was measured at 3 runner gap inspection pockets. Semi-circular corrosion was also observed at fillet weld of the new wearing ring-to-legacy parking ledge. No Sabi-Shut remained on

the corroded areas of the legacy parking ledge.

**2nd (Unit 4)**

A September 2019 inspection found corrosion in the original carbons steel portion of discharge ring immediately below the new Toshiba wearing ring (the legacy parking ledge area).
TAES study results: maximum depth 0.3" (7.6 mm).

During the May 2021 pond outage Toshiba applied paint coating (Sabi-Shut) in an attempt to slow the progression of corrosion in legacy parking ledge area.

A follow-up inspection was performed during the May 2022 MTB outage. Maximum corrosion depth exceeding 20 mm was measured at 3 runner gap inspection pockets. Corrosion was also observed at some locations between the runner gap inspection pockets and at the fillet weld of the new wearing ring-to-legacy parking ledge. No Sabi-Shut remained on the corroded areas of the legacy parking ledge.

**3rd (Unit 5)**

During the May 2021 pond outage inspection, it was observed that paint remains on almost the entire circumference of the legacy parking ledge and only slight corrosion was observed in those areas where paint was missing.

A follow-up inspection was performed during the June 2022 MTB outage. Paint remains on almost the entire circumference of the legacy parking ledge and only slight corrosion was observed in those areas where paint was missing.

**4th (Unit 6)**

An inspection was performed during the June 2022 MTB outage. Paint remains on almost the entire circumference of the legacy parking ledge and only slight corrosion was observed in those areas where paint was missing.

**5th (Unit 1)**

An inspection was performed during the April 2022 MTB outage. Paint remains on almost the entire circumference of the legacy parking ledge and only slight corrosion was observed in those areas where paint was missing.

### 3.4 Cause

#### 3.4.1 DRE NDE PT Indications

The classifications of PT indications were provided in Section 3.2. Based on Spring 2022 MTB outage inspections, possible causes are described below:

**Rounded indications**

a) Subsurface inclusions in the base material –

Inclusions inside the base material near the surface layer became exposed due to abrasion caused by running water during operation, or fine inclusions on the surface layer of the base metal is fallen off and the hole made by falling off became larger over time due to abrasion caused by running water during operation.

b) Unmelted portion of the weld (insufficient penetration) –

Subsurface unmelted residue in the welded part became exposed due to abrasion caused by running water during operation, or fine unmelted residue of a size smaller than the maximum allowable became larger over time due to abrasion caused by running water during operation.

c) Fine pinholes in welds –

Pinholes that had been inside near the surface layer of the welded part became exposed due to abrasion caused by running water during operation, or fine pinholes smaller than the maximum permissible size on the surface of the welded area became larger over time due to abrasion caused by running water during operation.

d) Micro blowholes in welds –

Blowholes that had been inside near the surface of the welded part became exposed due to abrasion caused by running water during operation, or fine blowholes below the maximum permissible size on the surface of the welded area became larger over time due to abrasion caused by runner water during operation.

e) Poor finishing of the weld bead –

The weld bead finish was poor and the PT dye penetrant could not be wiped off.

These rounded indications have not shown a tendency to progress further and it has been determined repairs are not required according to ECS2022K0203 criteria.

**Linear indications**

a) Fall-off of inclusions in the base material –

Inclusions inside the base material near the surface layer and became exposed due to abrasion caused by running water during operation, or fine inclusions on the surface layer of the base metal is fallen off and the hole made by falling off became larger due to abrasion caused by running water during operation.

b) Base material corrosion (upper draft tube) –

Corrosion due to peeling paint on the upper draft tube. Since the upper draft tube is carbon steel, it is natural that it will corrode if the paint peels off, which is a deterioration in normal operation. There is no problem as DRE is stainless steel.

c) Unmelted portion of the weld (insufficient penetration) –

The unmelted weld residue near the surface becomes exposed due to abrasion caused by running water during operation, or fine unmelted residue of a size smaller than the maximum allowable on the surface layer of the weld became larger due to abrasion caused by running water during operation.

d) Poor finishing of the weld bead –

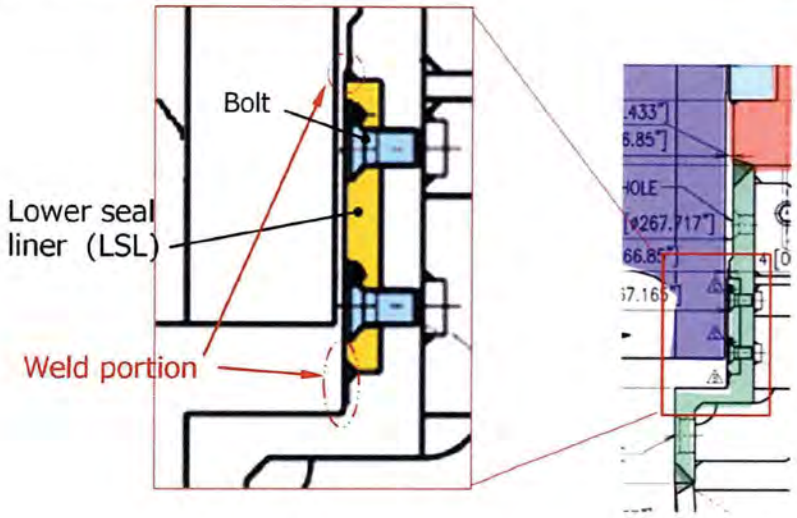
Weld bead finish was insufficient and PT penetrant could not be wiped off.

e) Burrs on the base material surface –

Inclusions that existed inside the base material became nearer to the surface layer due to field machining. As the base material on the upper part of the inclusion became thin a part turned up like a burr.

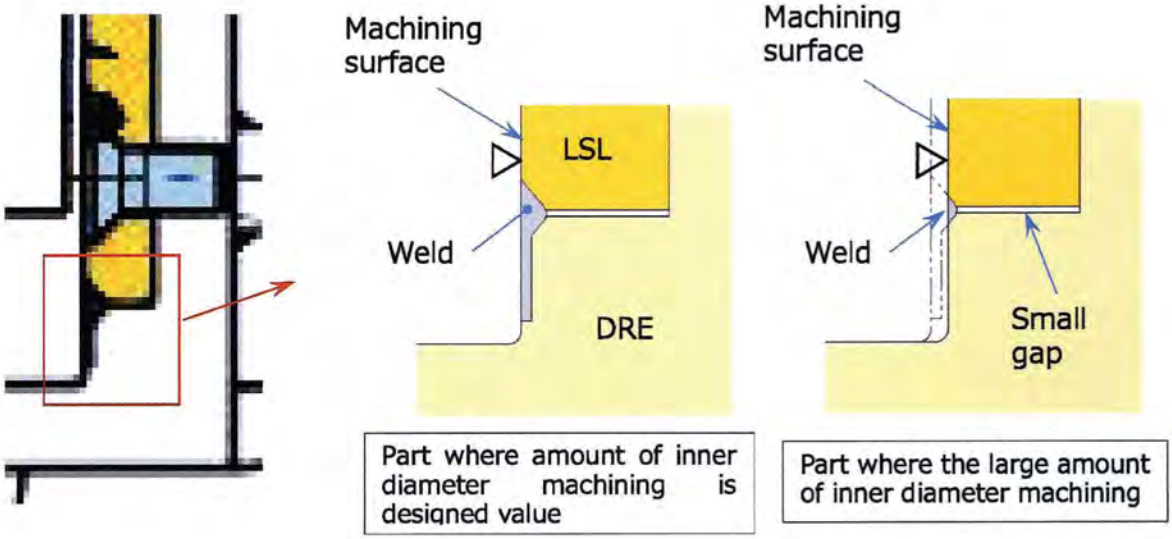
f) Unmelted portion of the weld under the lower seal liner (insufficient penetration) –

Units 5, 6, and 1 are equipped with a lower seal liner (LSL) which is affixed by bolts according to Toshiba's design concept. The top and bottom of the LSL are also seal welded as a supplementary fixation as per CEC's request. The seal weld on the bottom of the LSL is wider is for workability during the field welding process. As this weld is performed in an auxiliary sense, weld defects (due to insufficient penetration) do not require repair.




g) Gap between lower seal liner and DRE visible –

The inner diameter of the DRE is final machined in the field after installation, but there are variations in the amount of material removed circumferentially due to the DRE installation tolerance before machining. Therefore, those portions with larger amount of material removal during final machining are the areas where the weld thickness of the LSL to DRE seal weld becomes reduced. Cracks develop in the thinner seal weld areas and a small gap between LSL and DRE becomes visible. As explained in f), it is an auxiliary weld and Toshiba's design concept does not require repair. Also, repair is not required because there is no water leakage to the outside.



h) No visible scratches

A clear flaw this is not observable by microscope. It appears the dye penetrant chemical was left over from PT.

As of completion of the 2022 DRE NDE inspection outages all linear indications have been evaluated and repairs performed per ECSK2020H0203 criteria.

### 3.4.2 Corrosion of Unit 2 and Unit 4 legacy parking ledges

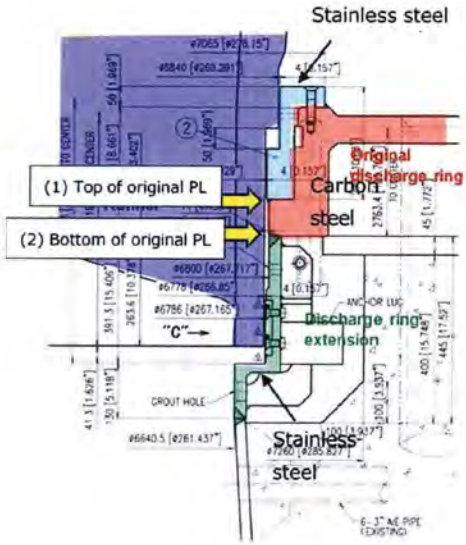
The progressive corrosion in Units 2 and 4 legacy parking ledges sections is thought to have occurred due to the following factors:

Units 2 and 4 are supplying air as countermeasures against runner self-excited vibration and we consider the air accelerated the corrosion on the legacy parking ledge area on those units.

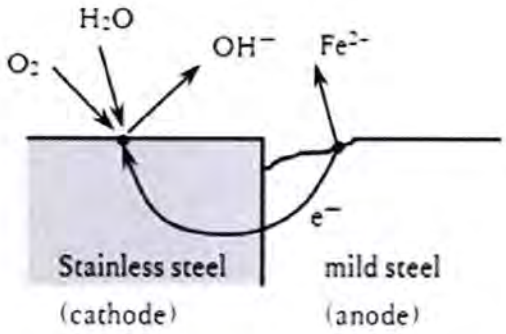
The form of corrosion itself is galvanic corrosion. The mechanism leading to corrosion is as follows –

The coating peels off due to the turbulence of the water flow, and the base material surface of the existing DR is exposed to the water flow. There is a stainless steel wearing ring on the upper side of the existing DR, and galvanic corrosion occurs in the DR near the wearing ring due to the potential difference between the stainless steel wearing ring and the carbon steel DR. Galvanic corrosion tends to progress when the area of the wearing ring is sufficiently large relative to the exposed area of the base metal of the existing DR.

In addition, Units 2 and 4 are supplying air, and that the amount of dissolved oxygen in water is relatively large and corrosion is accelerated.



Galvanic corrosion has the following mechanism.
When dissimilar metals having a large potential difference come into contact with each other in an electrolytic solution, one metal becomes an anode and the other metal becomes a cathode. This causes the anodic metal to corrode faster than a single metal in the electrolyte. This phenomenon is called galvanic corrosion.




For example, contact between stainless steel and mild steel in water. Because the potential of mild steel is lower than that of stainless steel, mild steel acts as an anode and stainless steel acts as a cathode causing mild steel corrosion.
The corrosion reaction formula is as follows.

Anode : $Fe \rightarrow Fe^{2+} + 2e^-$ ···(1)

Cathode : $1/2O_2 + H_2O + 2e^- \rightarrow 2OH^-$ ···(2)

Combine the above reactions,

$$Fe + 1/2O_2 + H_2O \rightarrow Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2 \quad \cdots\cdot(3)$$

$$2Fe(OH)_2 + H_2O + 1/2O_2 \rightarrow 2Fe(OH)_3 \rightarrow Fe_2O_3 \cdot 3H_2O \quad \cdots\cdot(4)$$

From the above formula, it can be seen that corrosion does not proceed in an environment where oxygen ($O_2$) and water ($H_2O$) are not supplied.
Therefore, covering the existing DR section, which is made of carbon steel, with a stainless steel overlay to shut it off from water and oxygen is an effective way to stop corrosion.

## 4 Toshiba Proposal

### 4.1 Toshiba's Proposal

Based on DRE inspection results through 2022, Toshiba proposes following:

- CEC performs DRE NDE inspections during each unit's 3 year planned preventative maintenance outage and utilizes Toshiba's ESCK2020H0203 inspection acceptance criteria to determine if repairs are required.
- Toshiba perform Unit 2 and Unit 4 legacy parking ledge repairs by means of partial unit disassembly as described below. Additionally, close off four pockets with plate.
- Main benefit of the partial disassembly method is to reduce the repair outage duration.

### 4.2 Unit 2 and Unit 4 Legacy Parking Ledge Repair Procedure

Figure 4.1 shows the repair work flow for repair of corroded area of Unit 2 and Unit 4 legacy parking ledges.

A conceptual diagram of repair is shown in Figure 4.2. Disassembly, repair, and re-assembly work steps include:

- Disassemble air cover, upper bearing, and UBB as work on the upper side of the generator.
- In parallel, parts around the lower guide bearing, turbine guide bearing, main shaft seal, and wicket gate operating mechanism are disassembled for jacking up the rotating parts and head cover.
- To avoid interference between the rotating parts and the head cover, the head cover is the raised up according to WOP for Jack up of Head Cover.
- The rotating parts are the raised up according to PRCK2022P0315 Procedure for jacking up/down of rotor (Appendix 4-1).
- Use 16 pcs x 100-ton jacks to jack up the rotating parts and raise it safety. The rotating parts are raised 400 mm and then supported and fixed crib-stacks or support blocks.
- Close off four pockets with plate according to drawing 1KQ008802.
- Hand grind off the corroded part between the DRE and the existing DR. Although the corroded conditions of the surface differ in the circumferential direction and the amount of grinding differs, the maximum depth of grinding is 20 mm.
- Complete repair by stainless steel weld overlay according to PRCK2022P0327 Repair Welding Procedure for DR U2 U4 (Appendix 4-2). Ensure a minimum weld thickness of 2.5 mm or more*.
- After welding, use hand grinder to smooth the surface.

- Following repairs, the rotating body is lowered to its original position, the head cover is lowered, and the upper side is assembled to complete the assembly.
- After completing the re-assembly, carry out a bearing heat run to complete re-assembly and return of unit to service.

*Regarding the welding deformation of the wearing ring caused by welding between the DRE and the existing DR, the results after welding in March 2021 were evaluated as follows.
Unit 3: WR deformation due to overlay welding when installing DRE is 0.3 to -0.1 mm in radius (+ is the direction of escape) (2021/3/23 measurement: WR deformation evaluation and corresponding ECS: ECSK2021H0114)

- Overlay amount of Unit 3 DRE is about 1.5 tons (15 x 6800 x $\pi$ x 600 x 7850/10^9 = 1509 kg)
- Overlay amount by overlay repair for Unit2/Unit 4: 72kg
  (5×6800× $\pi$ ×86.4×7850/10^9=72kg)

From the above, the amount is 5% of Unit 3, and it can be evaluated that there is almost no deformation.

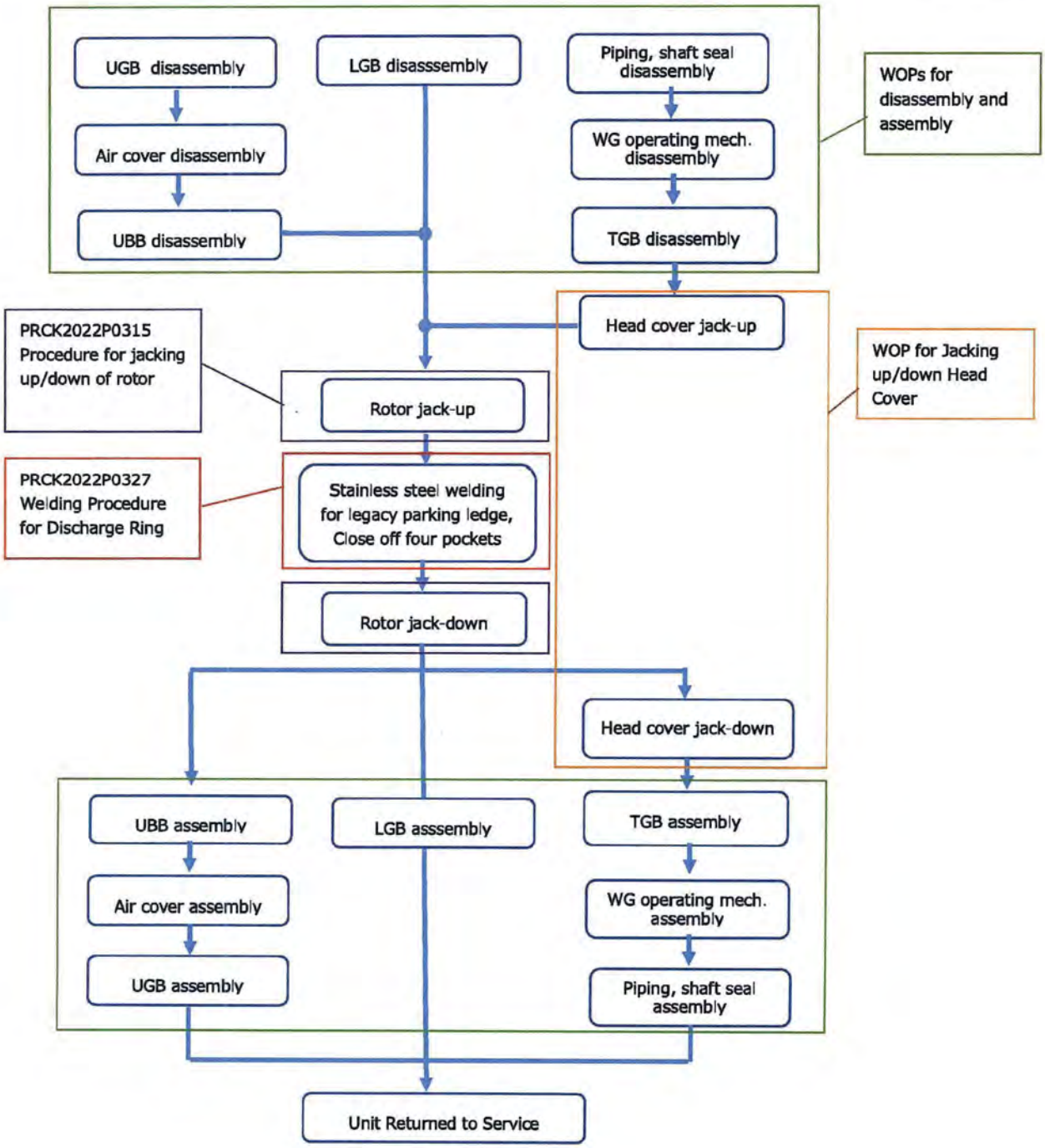



Figure 4.1 Repair Work Flow

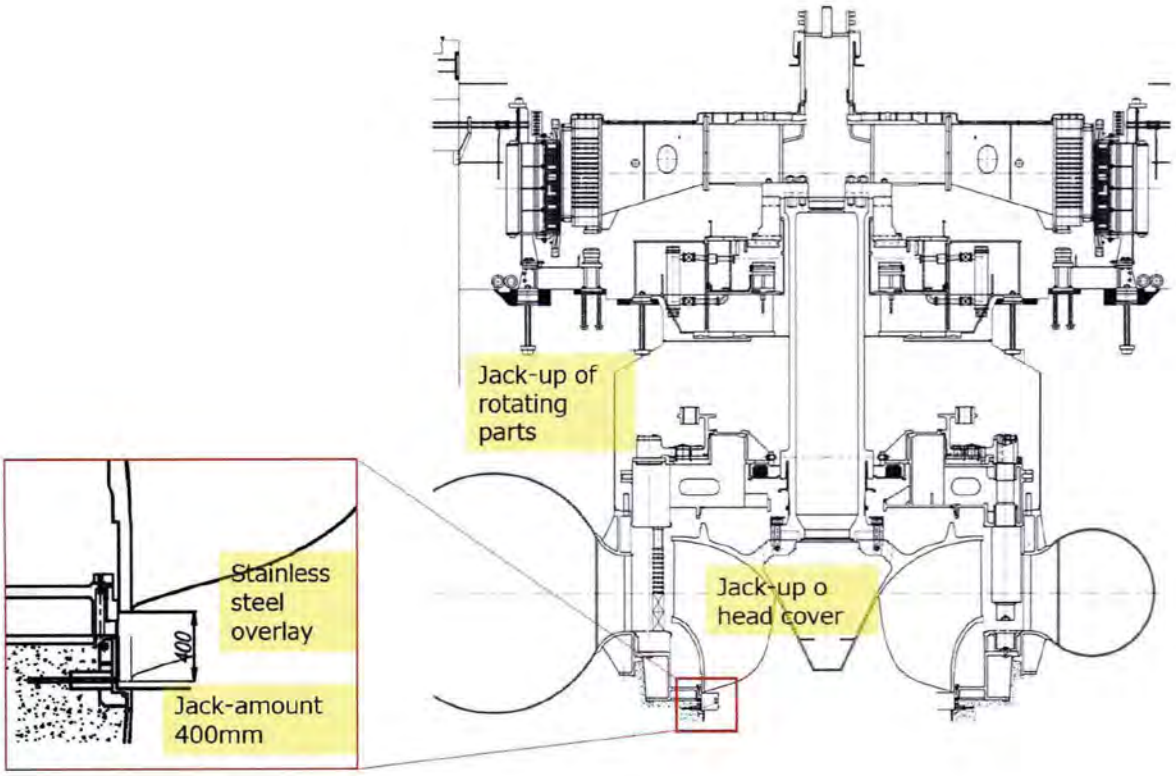
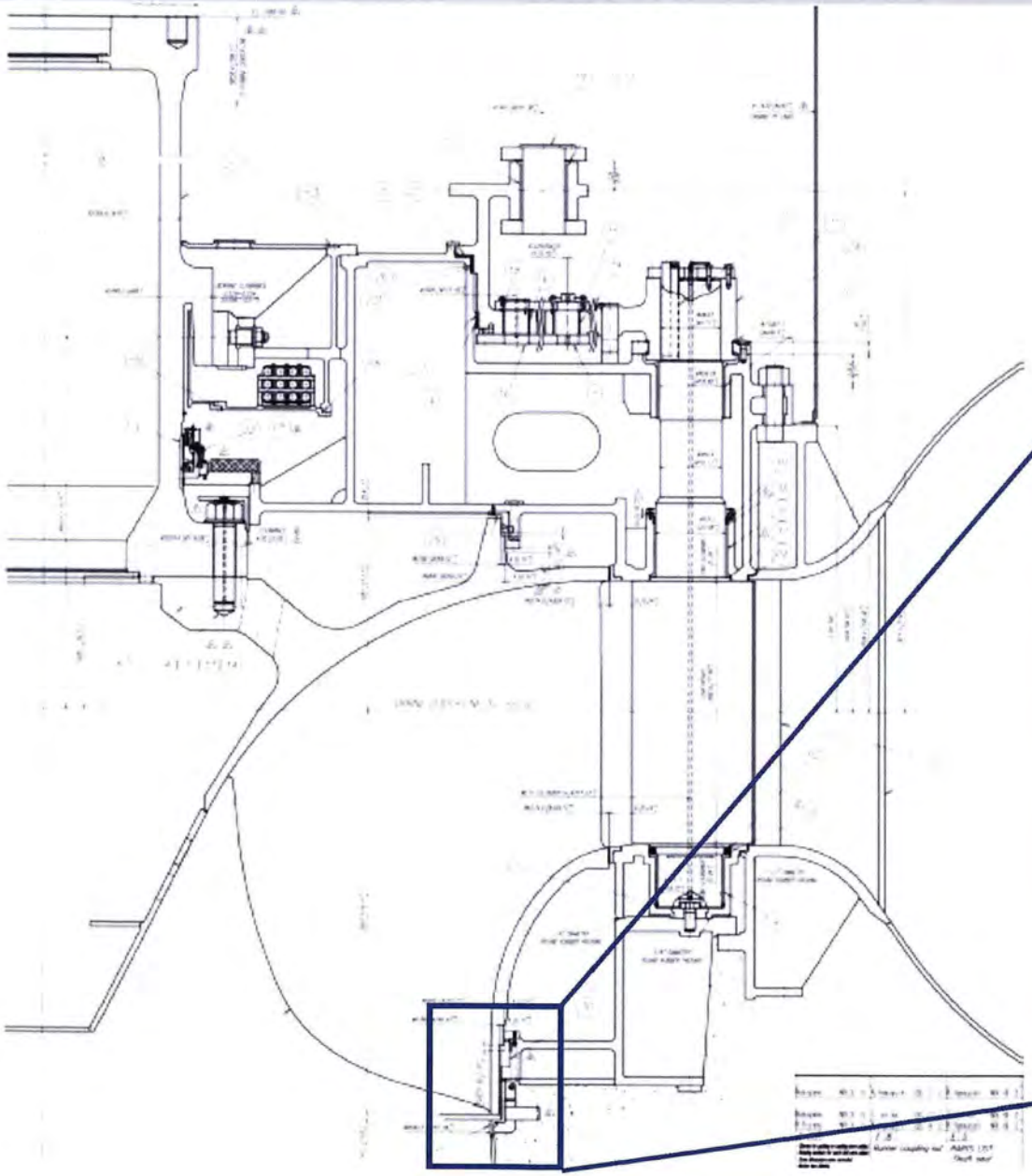



Figure 4.2 Conceptual diagram of repair

# Outline of Pump-Turbine Work

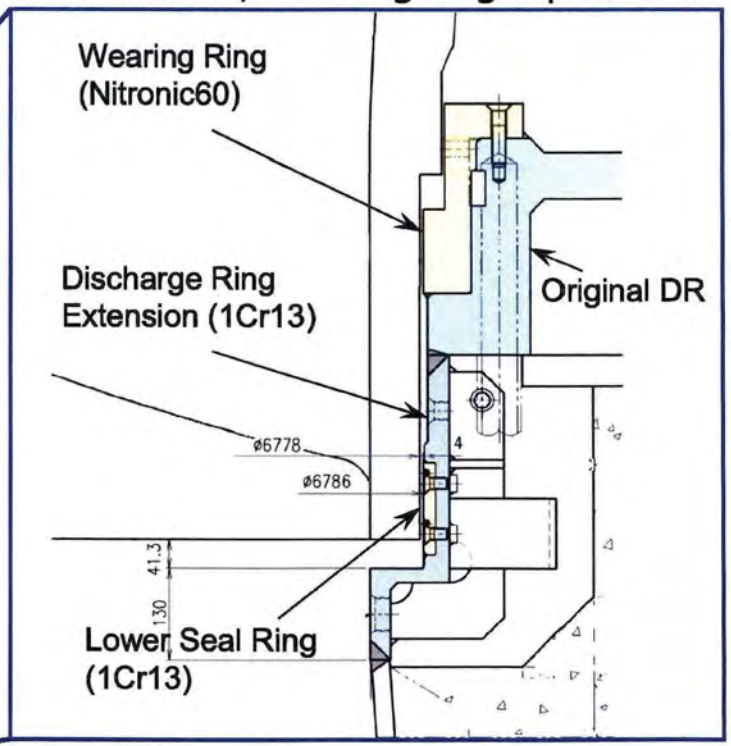


## Rating of Ludington Pumped Storage

| | |
|---|---|
| Rating※ | 312 MW → 360 MW / unit (Approx. 15% up) |
| Net Head (rated) | 320 feet (97.5 m) |
| Speed | 112.5 $min^{-1}$ |
| Number of units | 6 units |
| Operation | 2014-2019 |

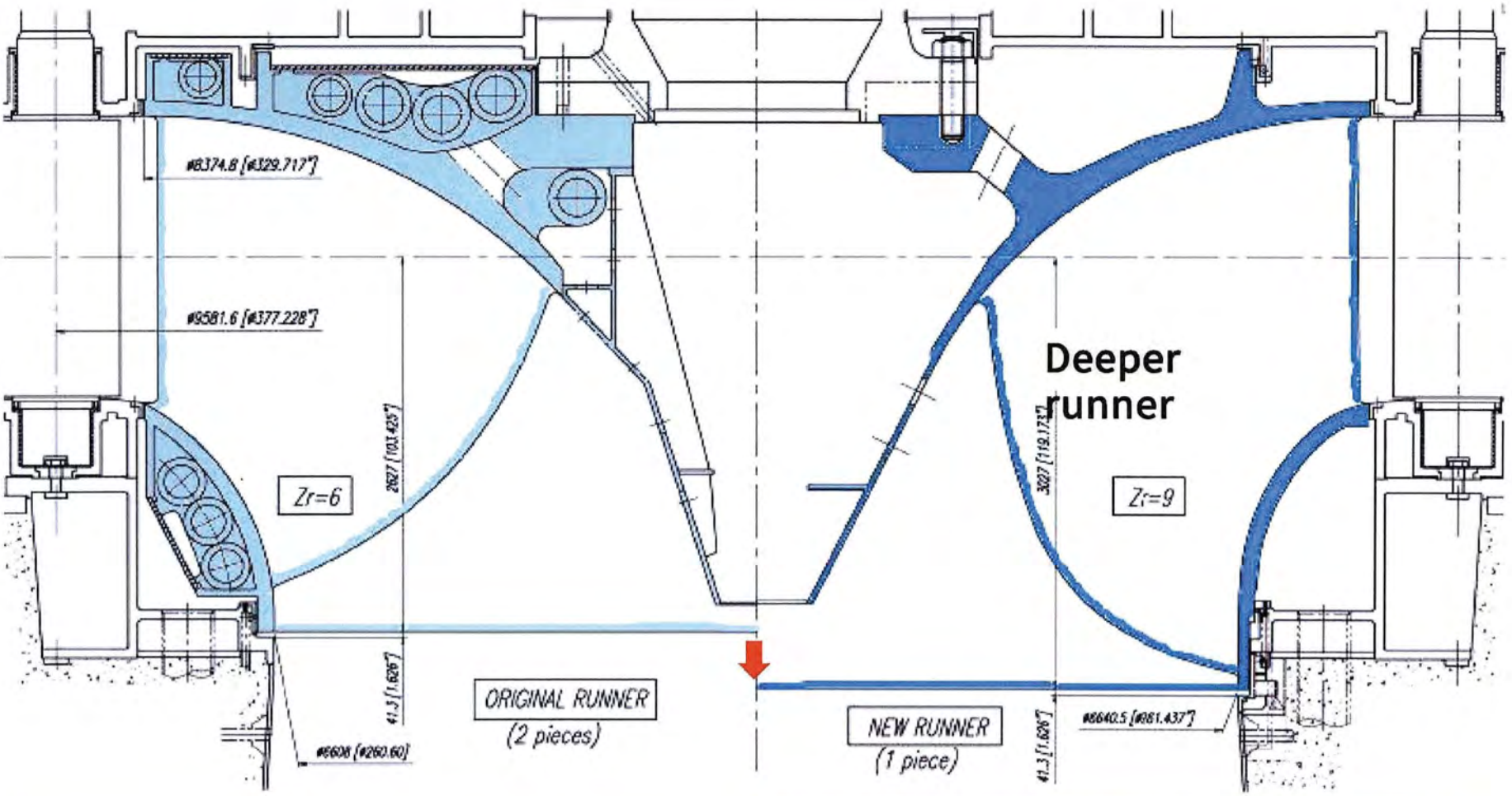
## Main Scope of Pump-Turbine work

Runner Replacement, Discharge Ring modification, Wearing ring replacement



# Deeper runner

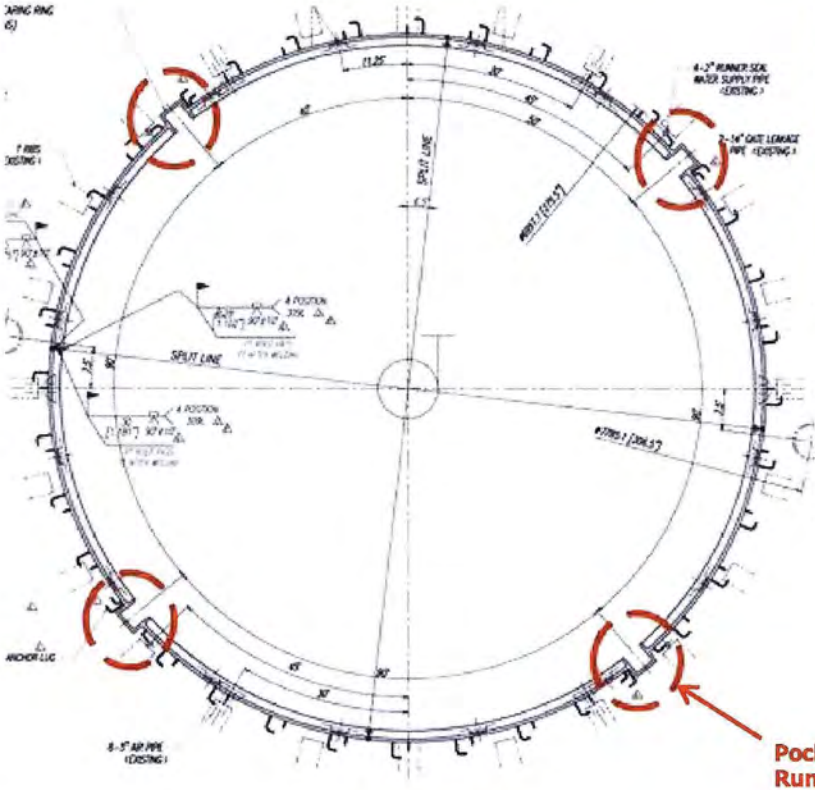



The Original runner had cavitation.

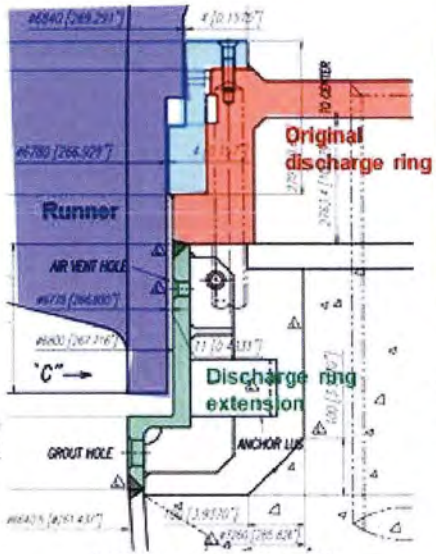
Extended runner vane downstream to improve cavitation performance.

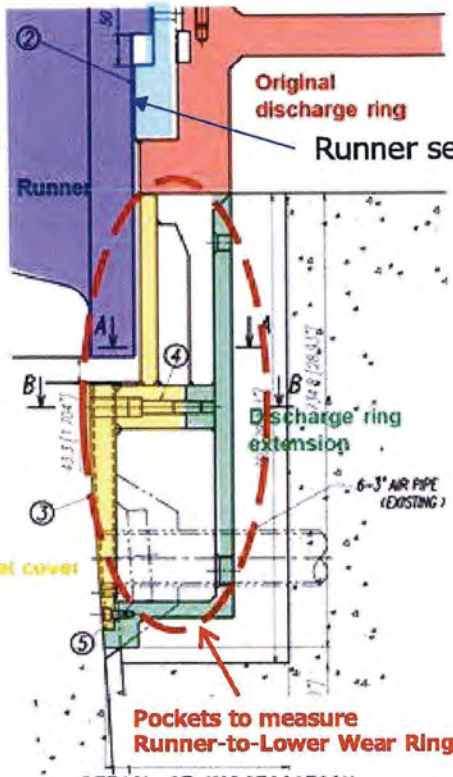
# Structure of DRE Units 2 and 4 (1st and 2nd units)




PLAN OF DISCHARGE RING EXTENSION PIECE




DETAIL OF MODIFICATION



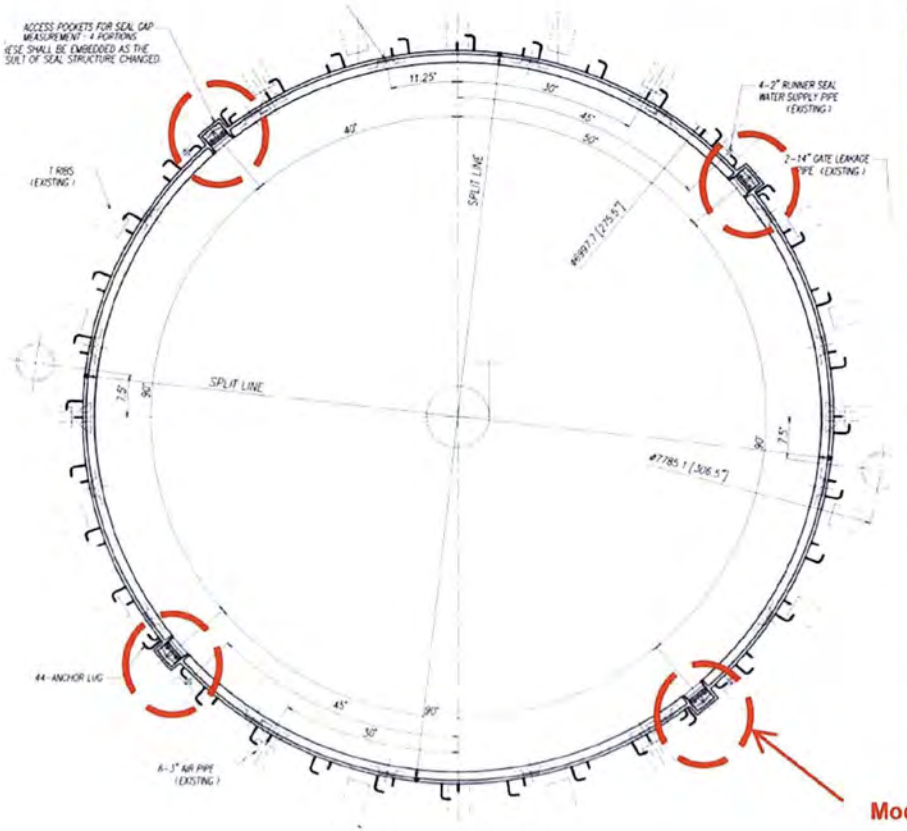

DETAIL OF MODIFICATION (ACCESS POCKETS)

Cross section of pocket area

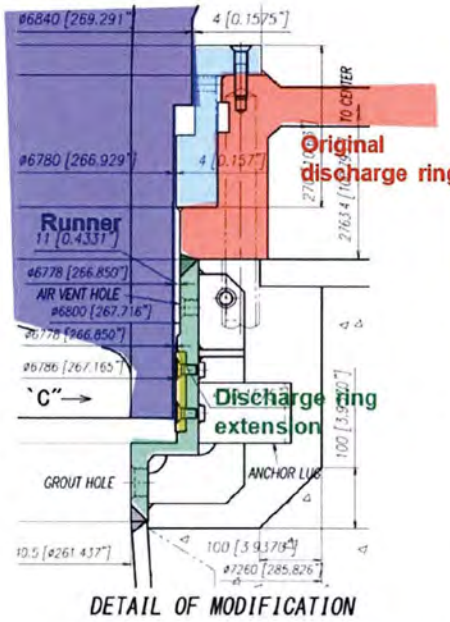

- 4 pockets for runner seal gap measurement.
- The pocket cover has been dropped in the past and is currently being removed and operated.

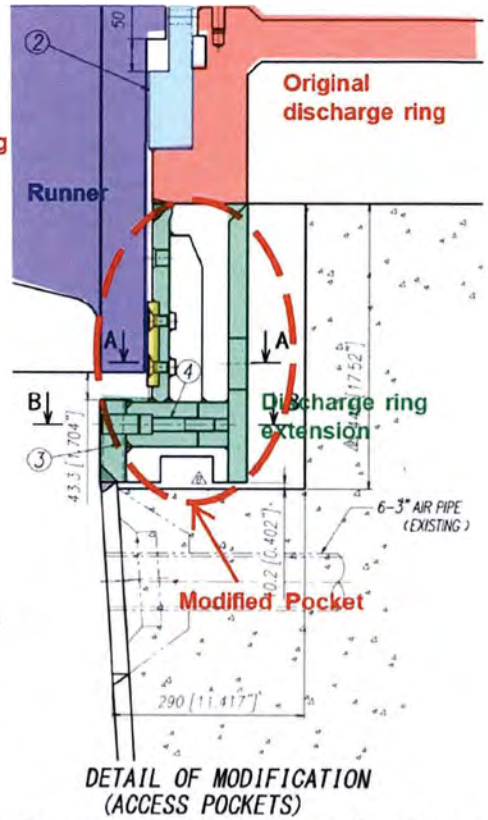
# Structure of DRE Unit 5 (3rd unit)




Plan of DRE




Cross section other than pocket area



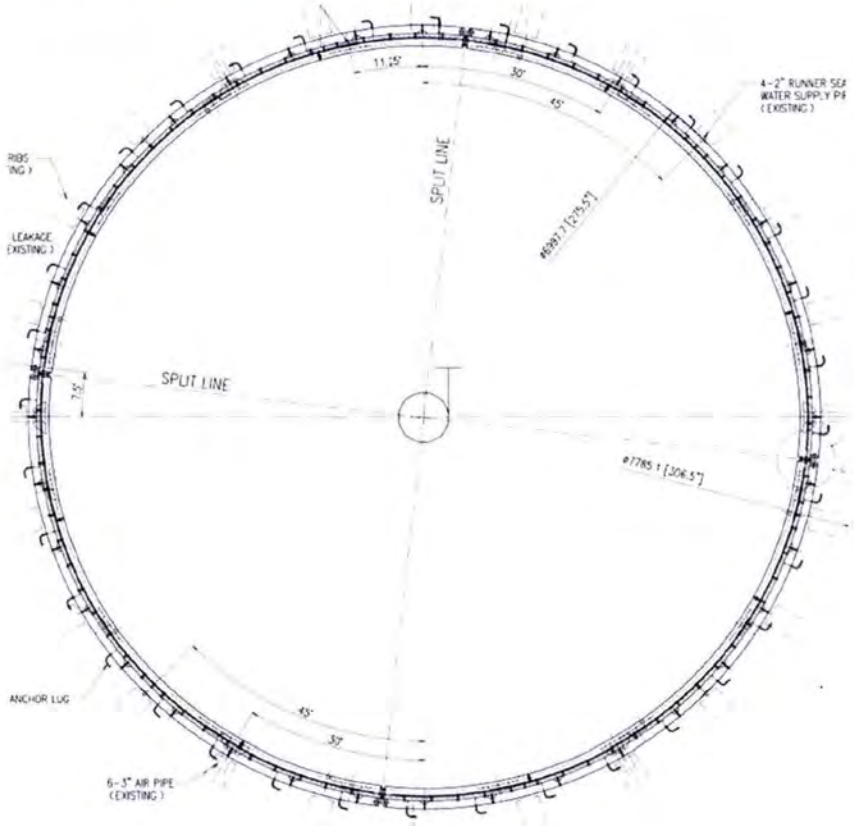

Cross section of pocket area

Modified the following at the factory before shipping

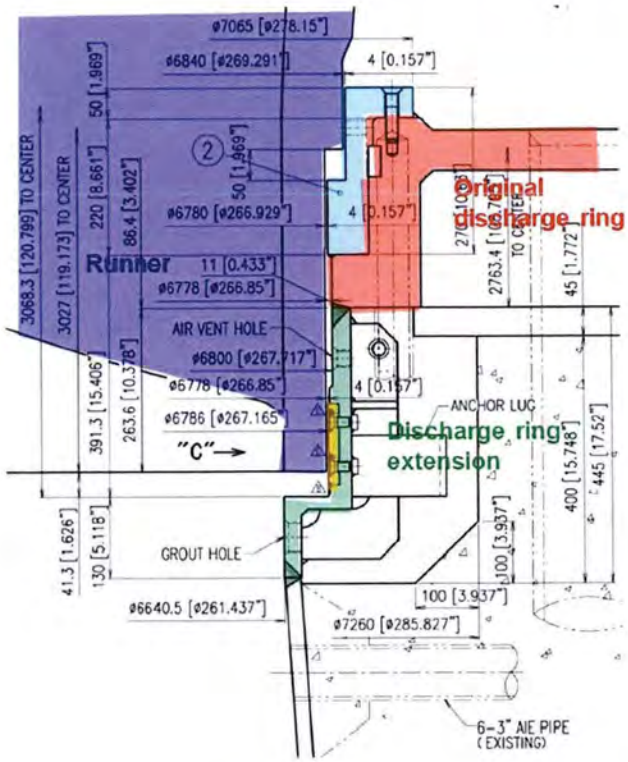
- Added a lower seal as a measure against runner self-excited vibration
- Pocket cover is completely fixed

# Structure of DRE Units 6 and 1 (4th and 5th units)




Plan of DRE




Cross section

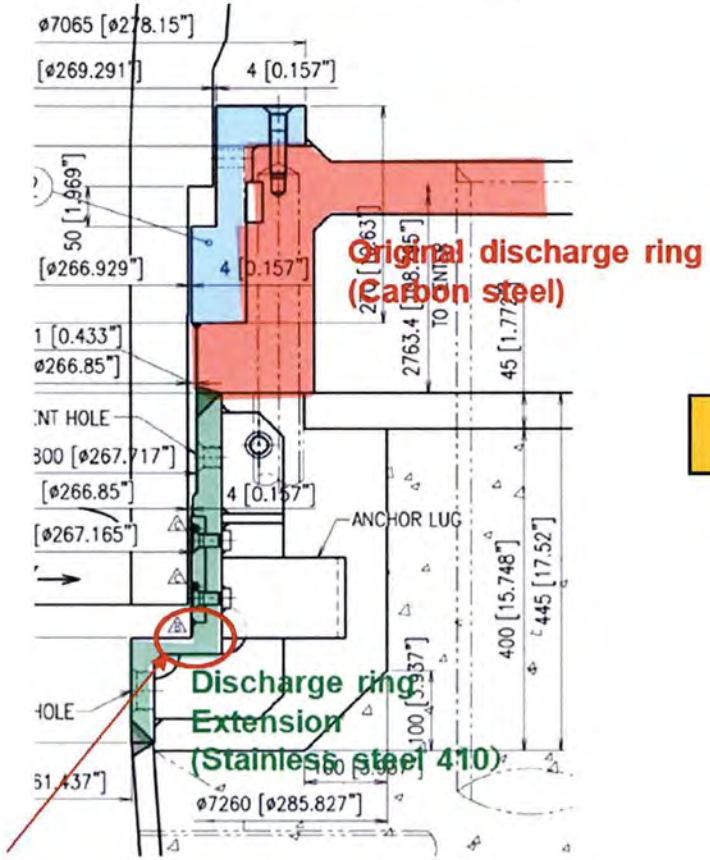
The following has been redesigned

- Added a lower seal as a measure against runner self-excited vibration
- There are no 4 pockets

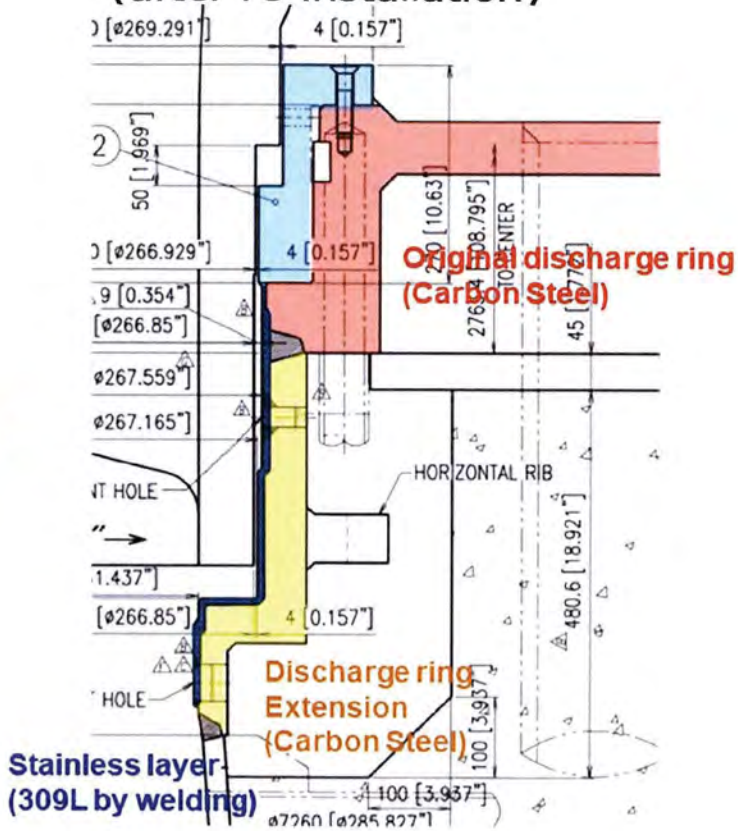
# Structure of DRE Unit 3 (6th unit)

## Initial structure (same as units 6 and 1)




Indications(cracks) occur in the Parking ledge corner during installation. The repair was repeated, but it was rejected.

## Final Structure (after re-installation)




The material and structure were changed and re-installed.

# Inspection and judgement criteria and repair method on DRE during operation



## Concept of the Inspection and judgement criteria and repair method

- Evaluate the required thickness/permissible flaw* size in advance.
- Evaluation can be done without performing strict calculations for each flaws found during inspection.
- It is a safe evaluation method in which there is no risk of development of flaws at the time of inspection.
- It is a logical repair method that does not require complete removal of cracks** based on a prior evaluation of the required thickness.

*: Flaw means the discontinuity or incomplete portion on the material
**: A progressive flaw to be repaired is defined as a crack

**Prior Evaluation**

Assumption of flaw

It is assumed that there is a large flaw on the parking ledge of the DRE primary weld.
Case1: If there are flaw all around
Case2: If there is semi-elliptical flaw with length 2.5m

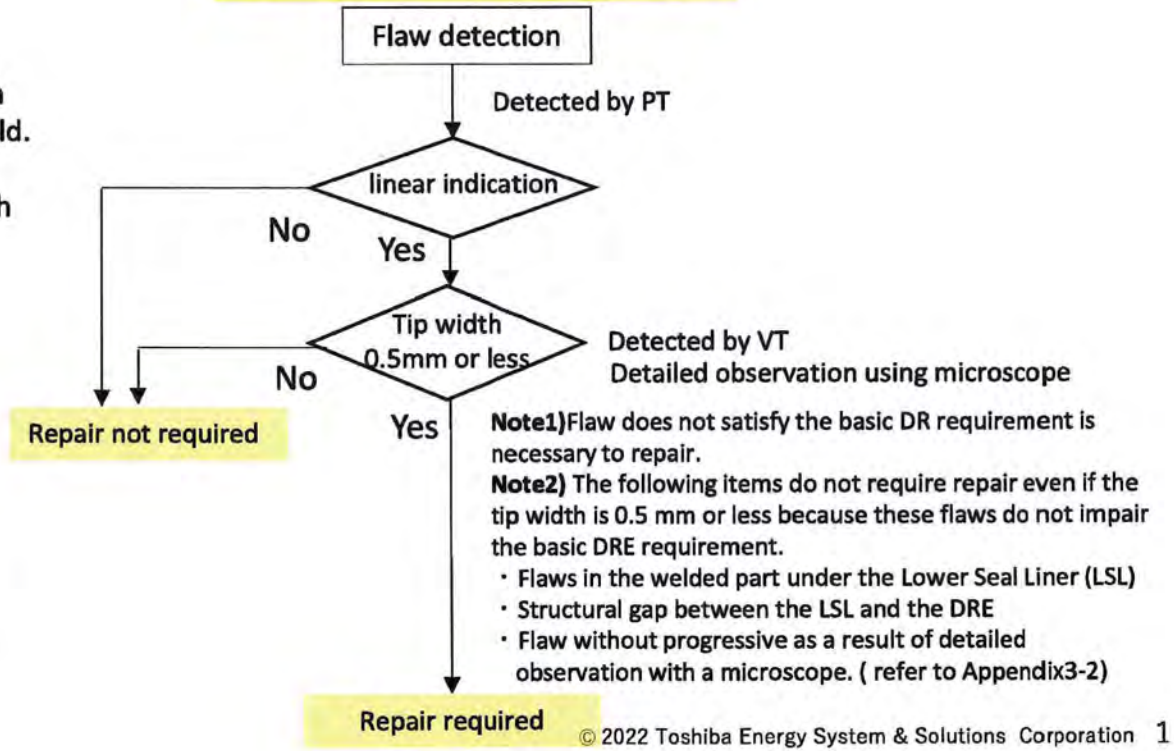
Evaluation of flaw

Calculation of flaw growth

Permissible residual thickness

- If the remaining thickness is 10 mm or more under both Case1 and Case2 condition, the crack does not grow. (EKQ004747)
- The fluctuating load of DRE is small, relatively large flaws can be tolerated.

**Evaluation of flaws during operation**




**Note1)**Flaw does not satisfy the basic DR requirement is necessary to repair.
**Note2)** The following items do not require repair even if the tip width is 0.5 mm or less because these flaws do not impair the basic DRE requirement.
- Flaws in the welded part under the Lower Seal Liner (LSL)
- Structural gap between the LSL and the DRE
- Flaw without progressive as a result of detailed observation with a microscope. ( refer to Appendix3-2)

# Inspection and judgement criteria and repair method on DRE during operation



The inspection and judgement are performed as in the following steps. Since it is difficult to understand the shape of the edge of flaw with PT alone, VT should be performed together with PT.

**Step 1:** A non-destructive PT is performed on the DRE and classified into linear indications and rounded indications. Rounded indications are non-progressive and do not require repair.

**Step 2:** Even if it is determined as a linear indication, VT determines whether the tip edge of the flaw is sharp or not.

**Step 3 (a):** Check the width of the tip edge of flaw by visual inspection. If the tip width is 0.5 mm or more, it is clearly not a crack, so it can be judged that there is no progress and can consider as a sufficiently safe evaluation.

**Step 3 (b):** The following items do not require repair even if the tip width is 0.5 mm or less because these flaws do not impair the basic DRE requirement.

- The flaws in the welded part under the Lower Seal Liner (LSL)
- The structural gap between the LSL and the DRE.
- If no growth is determined as a result of detailed observation with a microscope.

Appendix 3-2 shows sample photos of flaws. None of them require repair.

**Step 3 (c):** Any flaws judged to be progressing or those that do not satisfy the basic DR requirements are necessary to repair.

# Inspection and judgement criteria and repair method on DRE during operation



It is recommended that cracks are repaired as follows.

A. Those shall be excavated till those are removed by grinding, but the maximum depth is 0.2" (5mm). Excavated area shall be inspected by PT and if the results are within criteria of ASME Sec.Ⅷ Div.1 Appendix 8, those are left as is. It is not necessary to repair the ground area by welding.

B. If the indications still remain after 0.2" depth excavation, those shall be excavated till those are removed by grinding, but the maximum depth is 0.4" (10mm). After excavation, those areas shall be repaired by welding, then shall be grinded in order to get smooth surface. After grinding smoothly, those shall be inspected by PT. Acceptance criteria: ASME Sec.Ⅷ Div.1 Appendix 8.

The suitable WPS shall be used for welding repair.

# Inspection and judgement criteria and repair method on DRE during operation



## Supplementary explanation

Since DRE has a small repetitive stress amplitude during operation, it is not necessary to repair flaws that are clearly not progressive.

- To determine whether or not the flaw is progressive, it is checked whether the tip of the flaw is sharp. "Sharp" means that the width of the tip is almost zero, but as a judgment criterion for screening this easily and safely, a threshold of 0.5 mm in width of the tip of the flaw was set.

- If the width of the tip of the flaw is 0.5 mm or more, it does not include flaws that are progressive. If the width of the tip of the flaw is 0.5 mm or less, it does not necessarily mean that the flaw is progressive. But it is a sufficiently safe threshold to not miss progressive flaws.

- Check the width of the tip by VT. As a sufficiently safe evaluation, if the tip width is 0.5 mm or more, it is clearly not a crack, so it can be judged that there is no progress.

# Inspection and judgement criteria and repair method on DRE during operation

## Supplementary explanation

- Even if the tip width is 0.5 mm or less, there is no need to repair if it is determined that there is no growth as a result of detailed observation with a microscope.

- In addition, The following items do not require repair even if the tip width is 0.5 mm or less because these flaws do not impair the basic DRE requirement.

  - The flaws in the welded part under the Lower Seal Liner (LSL)
  - The structural gap between the LSL and the DRE

  LSL is fixed by bolts and also the top and bottom of LSL is welded. In Toshiba's design concept, it is normal to fix the liner only with bolts, not just LSL. As for the LSL, it is sufficient to fix it with only bolts, but the top and bottom of the LSL are welded as a supplementary fixation of the LSL according to the customer's request. Originally, welding is performed in an auxiliary sense, so there is no problem even if this welded portion is not present.

- The photograph in Appendix 3-2 shows as an example that does not require repair

- Based on a prior evaluation of required thickness calculated from crack propagation calculation, it is not necessary to remove the crack completely. It is rational repair method.

# Inspection and judgement criteria and repair method on DRE during operation

## Validity of sharp tip width 0.5mm

It is explained that the value of 0.5mm is sufficiently safe, based on the concept of test piece shape in material test.

- The notch shape of the impact test piece (Charpy test piece) is R0.25 mm, and the width is 0.5 mm. In other words, it is considered that a slit of 0.5 mm width for impact test piece is not a crack.
- JIS G0564 is a plane strain fracture toughness test method, which measures the fracture toughness value using notched test pieces in which fatigue pre-cracks are introduced. The shape of the notch for fatigue crack initiation in this test piece is shown in Fig. 2 in Sections 7.2.4. The notch tip radius is 0.1 mm or less, and a pre-crack is generated from there. That is, it can be seen that the width of 0.2 mm at the tip of the notch is not regarded as a crack.
- From the above, it can be seen that the threshold value of 0.5 mm in width of the tip of a flaw is sufficiently safe to catch progressive flaws.

# Inspection and judgement criteria and repair method on DRE during operation



## Validity of sharp tip width 0.5mm

JIS G0564 :plane strain fracture toughness test method

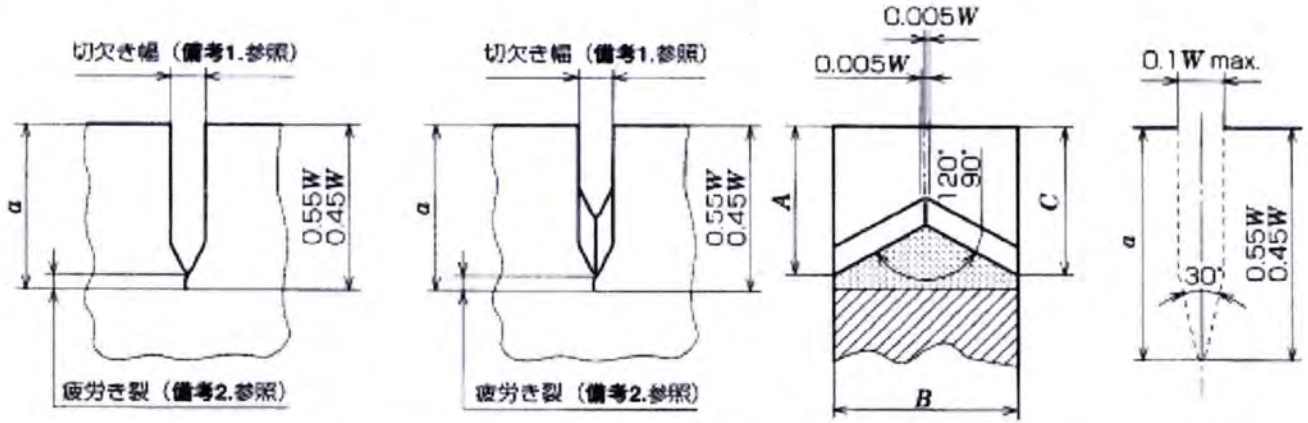
### 7.4.2 Notch for crack initiation

G 0564 : 1999 (ISO 12737 : 1996)

**7.2.4 疲労き裂発生用切欠き** 2種類の疲労き裂発生用切欠きの形状を，図2のa)及びb)に示す。先端がVノッチの直線状の貫通切欠きの先端底半径は0.10 mm又はそれ以下である。シェブロン形状の切欠きに対する先端底半径は0.25 mm又はそれ以下を推奨する。切欠きの製作方法は特に規定していない。き裂発生用切欠き(疲労き裂を加える)は，図2 c)の点線で示す外郭線の内に入っているものとする(附属書A参照)。

変位計を取り付けるための2種類のナイフエッジを，図3に示す。

The tip base radius of the V-notched straight through notch is 0.1 mm or less.




a) 直線状の貫通型切欠き　　b) シェブロン型切欠き　　c) 外郭線

備考1. き裂発生用切欠きは，試験片表面に対し±2°内で垂直とする。切欠き幅は，0.1Wを超えてはならないが1.6 mmより小さい必要はない。

2. 直線状の貫通型切欠き：推奨切欠き底半径は最大0.10 mm。カッタ先端角度は最大90°。試験片各表面の疲労き裂進展は，最小0.025Wか1.3 mmのいずれか大きい方とする。

3. シェブロン型切欠き：推奨切欠き底半径は最大0.25 mm。カッタ先端角度は最大90°とし，A＝Cでその差は±0.01W内とする。疲労き裂は，試験片の両表面上に現れてなければならない。

図2 き裂発生用切欠きと最大許容切欠き/き裂外郭線

# Inspection and judgement criteria and repair method on DRE during operation



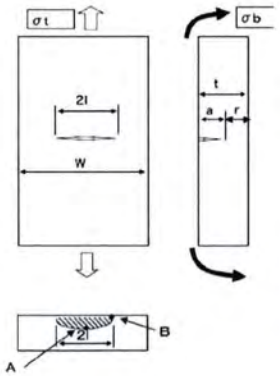
## Validity of repair method of sharp tip indication

EKQ004747 Crack propagation calculation ECSK2020H0056 Static stress analysis by FEM

| Pressure Condition | A(Normal) | | B(SE Vib) ⚠ | | | |
|---|---|---|---|---|---|---|
| Case | Case A1 | Case A2 | Case B1 | Case B2 | | |
| | r=2mm (a=28) | r=10mm (a=20) | r=2mm (a=28) | r=10mm (a=20) | | |
| Crack Depth a= | 28 | 20 | 28 | 20 | Mm | |
| Crack Length 2l | 2500 | 2500 | 2500 | 2500 | Mm | Assumption |
| Plate Thickness t | 30 | 30 | 30 | 30 | Mm | |
| Plate Width W | 6000 | 6000 | 6000 | 6000 | mm | Assumption |
| $\phi$ at point A | 1.5708 | 1.5708 | 1.5708 | 1.5708 | radian | |
| W | 6000 | 6000 | 6000 | 6000 | mm | |
| a | 28 | 20 | 28 | 20 | mm | |
| l | 1250 | 1250 | 1250 | 1250 | mm | |
| $\zeta$ =a/l | 0.02 | 0.02 | 0.02 | 0.02 | - | |
| t | 30.00 | 30.00 | 30.00 | 30.00 | mm | |
| a/t | 0.93 | 0.67 | 0.93 | 0.67 | - | |
| Ft | 10.632 | 4.739 | 10.632 | 4.739 | - | |
| Fb | 3.044 | 1.940 | 3.044 | 1.940 | - | |
| $\Delta\sigma$t | 0.037 | 0.037 | 0.076 | 0.076 | kgf/mm2 | |
| $\Delta\sigma$b | 0 | 0 | 0 | 0 | kgf/mm2 | |
| $\Delta$K | 3.72 | 1.40 | 7.61 | 2.87 | kgf/mm^(3/2) | |
| | 1.15 | 0.43 | 2.36 | 0.89 | MN/m^(3/2) | |
| | ≒ $\Delta$Kth | ≦ $\Delta$Kth | ≒ $\Delta$Kth | ≦ $\Delta$Kth | | |

In the case of caseB1 (at Self Excited Vibration Condition, remained depth r=2mm), crack will propagate by pressure fluctuation.
In other cases, crack does not propagate.

Evaluation when the remaining plate thickness is 2 mm and 10 mm during normal operation, because the fluctuating stress is small enough. None of them develop cracks.



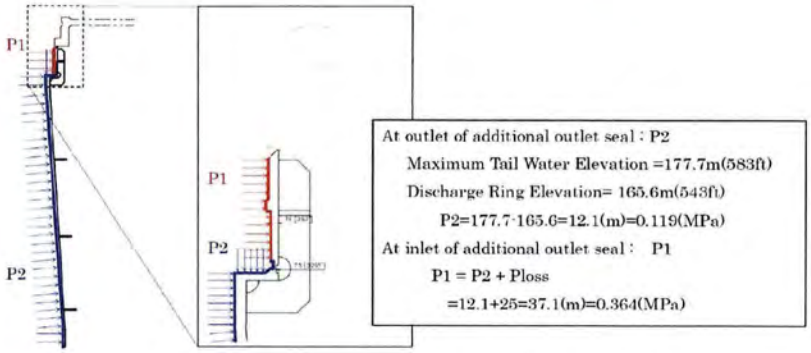




Fig.3-A1: Load condition by hydraulic pressure (during operation)

3. FEA result
3.1 [Case A] Operational condition (during operation)

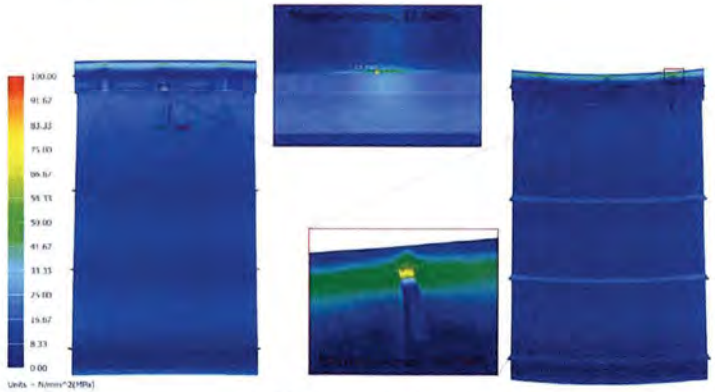


Fig.4-A1: Maximum Von Mises stress

The required welding thickness is 10mm in consideration of static and fatigue strength.

# Sample Photo for Flaw Discrimination

The following pages show sample photographs to judge the necessity of repairing flaws.

All samples show no repair required.

- Sample A-1~A-6
  Round indication
  These are judged to have no progressive by microscope observation.

- Sample B-1~B-7
  Linear indication
  These are judged to have no progressive by microscope observation.

- Sample C-1~C-4
  Flaw in the welded part under the Lower Seal Liner (LSL) and the structural gap between the LSL and the DRE
  These flaws do not impair the basic DRE requirement.

- Sample D-1~D-3
  PT indication was recorded but no flaws were observed by microscope observation.

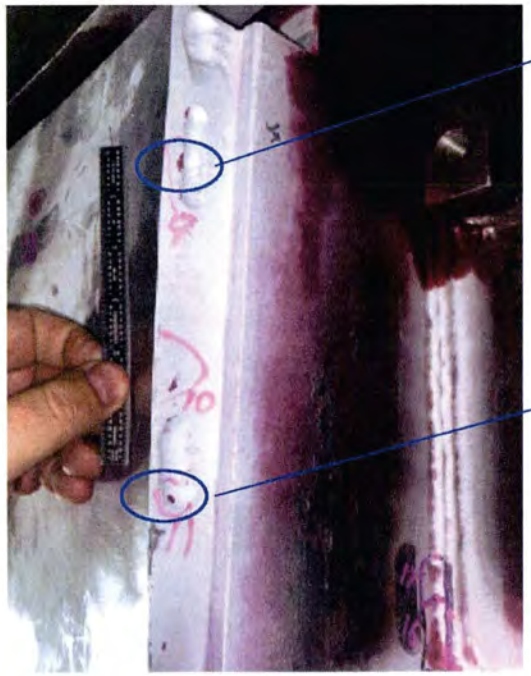
# Sample A-2

**Rounded indication:** Minor inclusion of material

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 9 | * | 9.17 | * | * | REJECT | 2019 | Previous rejections. Excavated |
| 11 | * | 9.17 | * | * | REJECT | 2019 | Previous rejections. Excavated |

Observation with microscope



Rounded indication
A inclusion of the material was exposed due to wear at the previous repair portion.
Not progressive

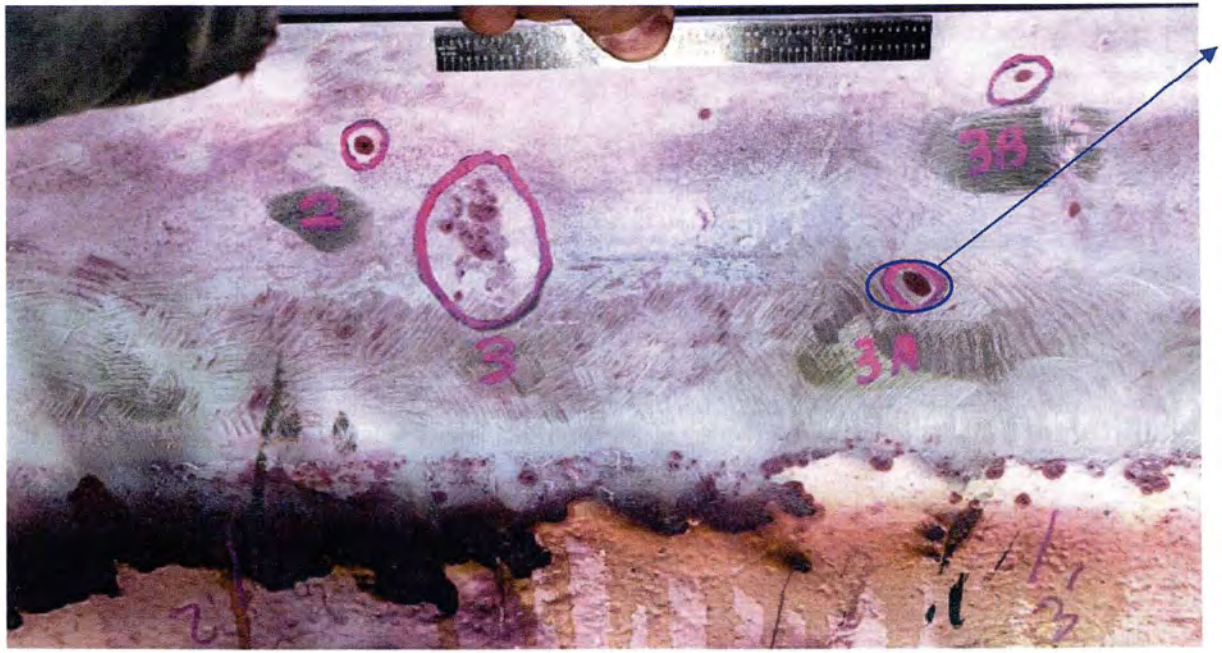
 

# Sample A-1

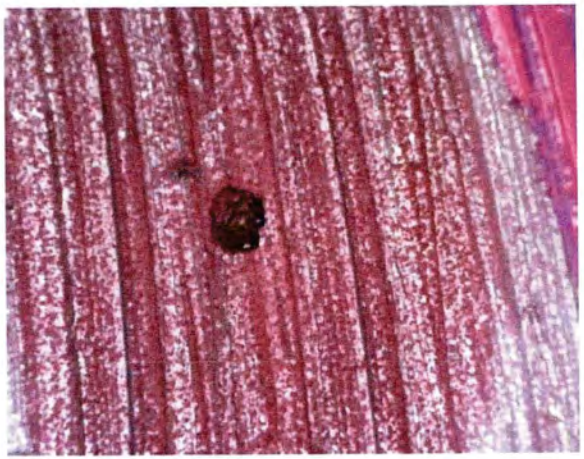
**Rounded indication:** Minor inclusion of material

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 3A | * | 2.80 | Rounded | 3/8" | REJECT | 2022 | Lower Vertical Plate |




Observation with microscope



Reference value
↔ 1mm(参考値)

Rounded indication
A inclusion of the material was exposed due to wear.
Not progressive

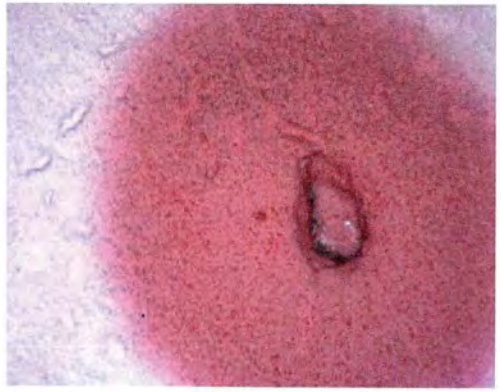
# Sample A-3

**Rounded indication:** minor unmelted portion of weld

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 3C | * | 3.60 | Rounded | 3/8" | REJECT | 2022 | Lower Vertical Plate |


Observation with microscope



Reference value
1mm(参考値)

Rounded indication
A minor unmelted portion of weld was exposed due to wear.
Not progressive

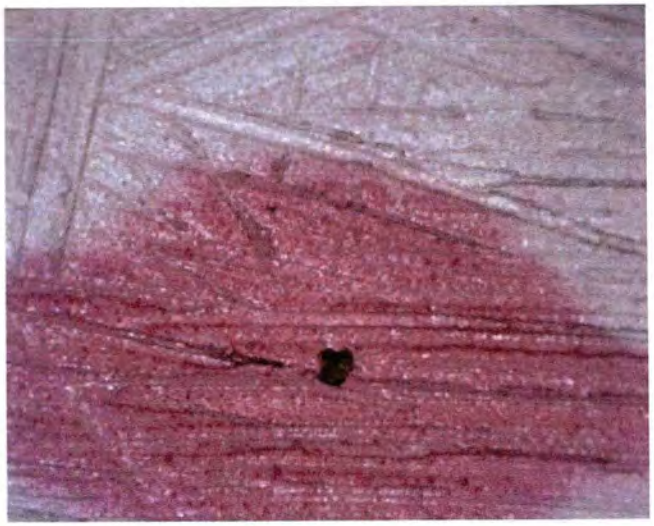
# Sample A-4

**Rounded indication:** Minor pinhole of weld

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 1B | * | 1.30 | Rounded | 3/8" | REJECT | 2022 | Lower Vertical Plate |


Observation with microscope



Reference value
1mm(参考値)

Rounded indication
A minor pinhole inside the weld was exposed due to wear.
Not progressive

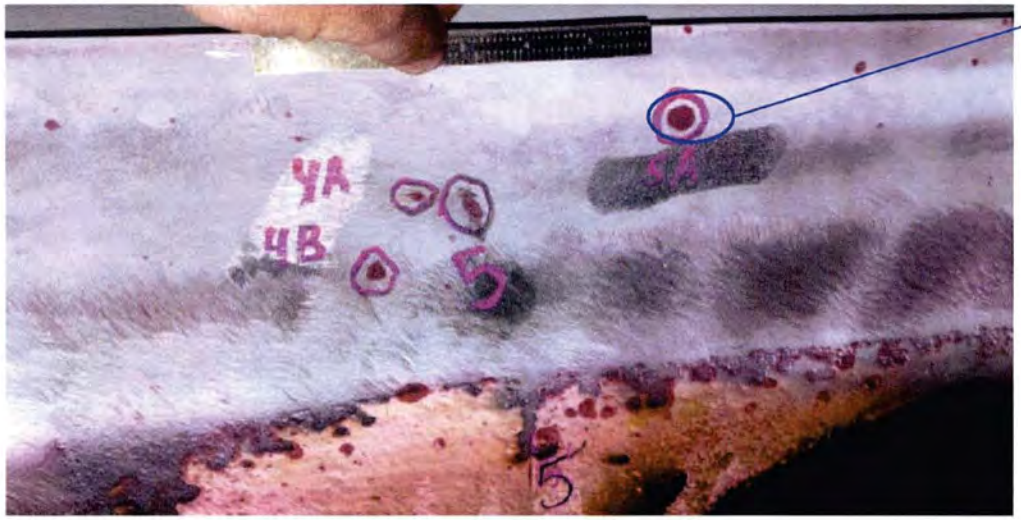
 

# Sample A-5

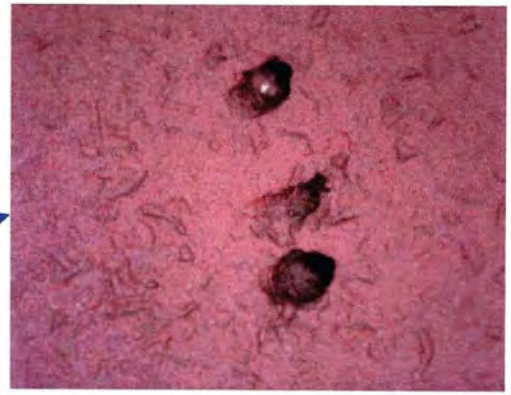
**Rounded indication:** minor blow hole of weld

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 5A | * | 5.25 | Rounded | 5" | REJECT | 2022 | Lower Vertical Plate |




Observation with microscope



Reference value
1mm(参考値)

Rounded indication
A minor blow hole of weld was exposed due to wear.
Not progressive

# Sample A-6

**Rounded indication:** Insufiscient finish of weld bead

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 13 | * | 9.19 | Rounded | 1/4" | REJECT | 2019 | Previous rejections. Excavated |

Observation with microscope

Rounded indication
Insufficient finish of weld bead. Not progressive

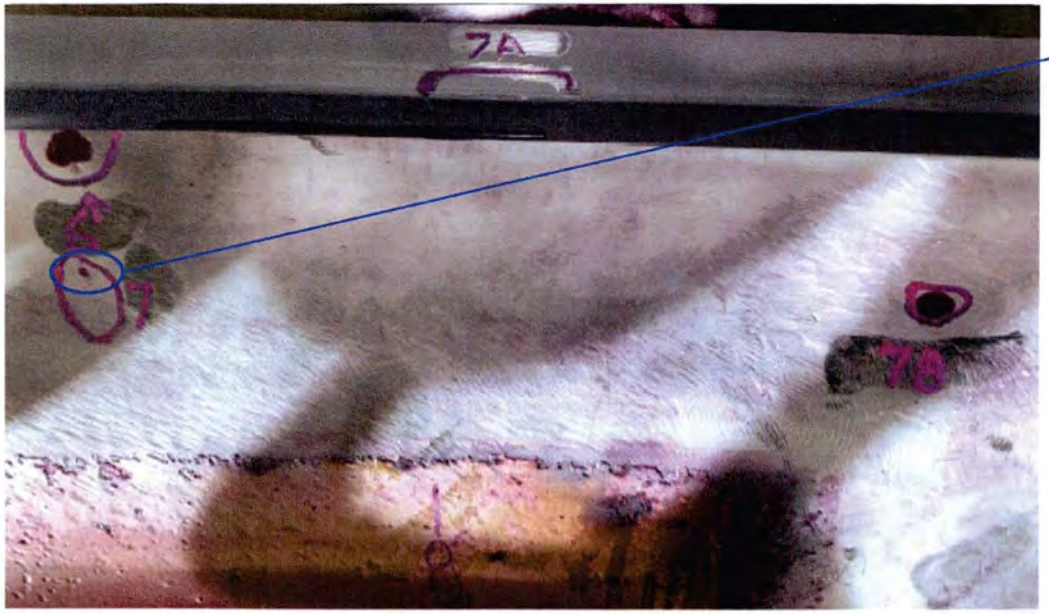
 

# Sample B-1

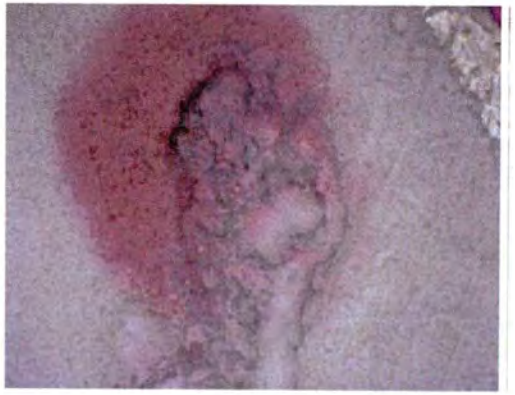
**Linear indication:** Inclusion of material

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 7 | * | 7.52 | Linear | 1" | REJECT | 2019 | Lower Vertical plate. |




Observation with microscope



Reference value
1mm(参考値)

Linear indication
A inclusion of material was exposed due to wear.
Not progressive

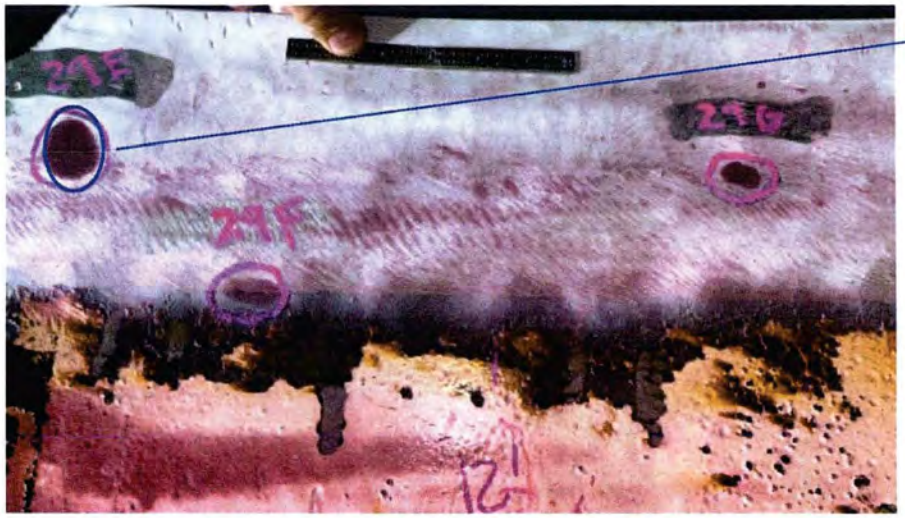
 

# Sample B-2

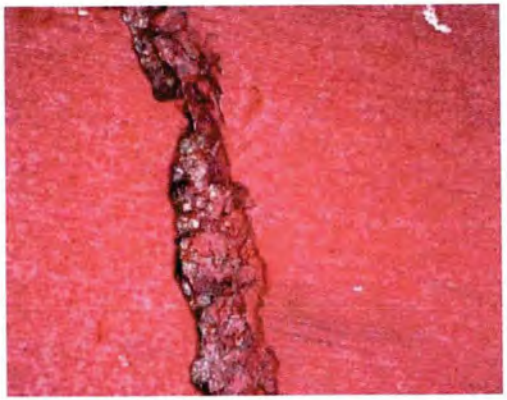
**Linear indication:** Inclusion of material

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 29E | * | 11.00 | Linear | 1/2" | REJECT | 2022 | Lower vertical plate |




Observation with microscope



Reference value
1mm(参考値)

Linear indication
A inclusion of material was exposed due to wear.
Not progressive

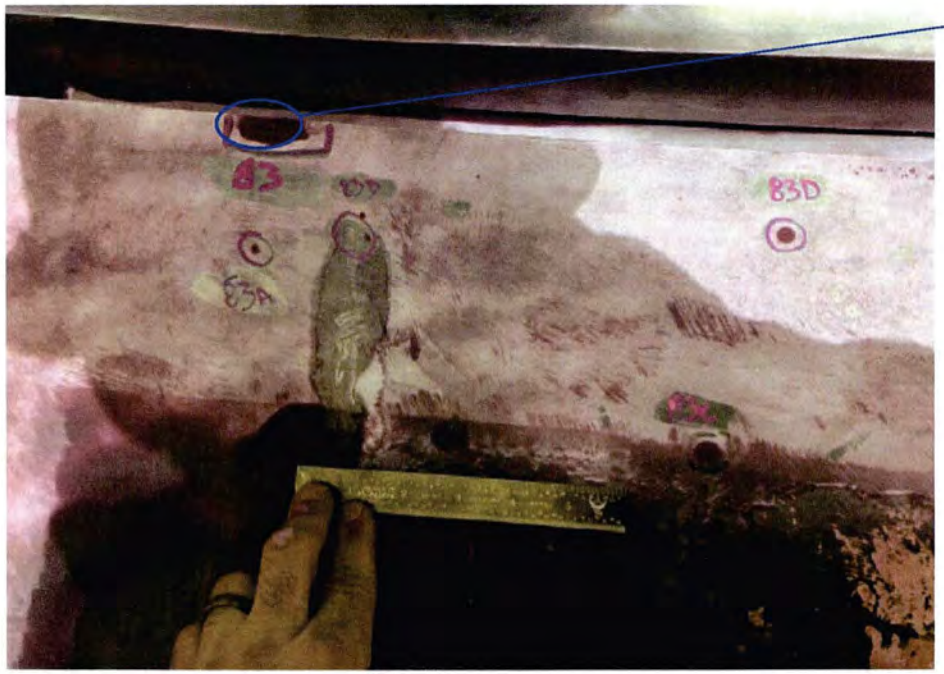
 

# Sample B-3

**Linear indication:** Inclusion of material

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 83 | * | 44.60 | Linear | 1.25" | REJECT | 2019 | Lower Vertical Plate |




Observation with microscope

Linear indication
A inclusion of material was exposed due to wear.
Not progressive

# Sample B-4

**Linear indication:** Corrosion

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 32 | * | 9.70 | Linear | * | REJECT | 2019 | Previous rejections. Excavated |

Observation with microscope

Reference value
1mm(参考値)

Linear indication
Corrosion of upper draft tube which material is carbon steel.

# Sample B-5

**Linear indication:** minor unmelted portion of weld

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 29H | * | 13.50 | Linear | 1/2" | REJECT | 2022 | Lower vertical plate |

Observation with microscope

Reference value
1mm(参考値)

Linear indication
A minor unmelted portion of weld was exposed due to wear.
Not progressive

# Sample B-6

**Linear indication:** Insufficient finish of weld bead

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 12 | * | 9.20 | Linear | .5" | REJECT | 2019 | Lower Vertical plate. |

Observation with microscope

Reference value
1mm(参考値)

Linear indication
Insufficient finish of weld bead. Not progressive

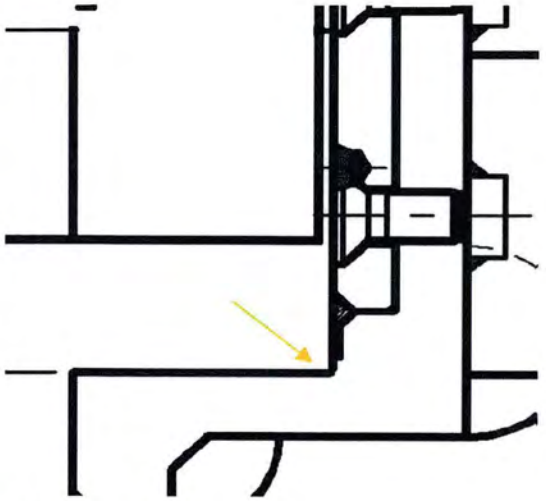
 13

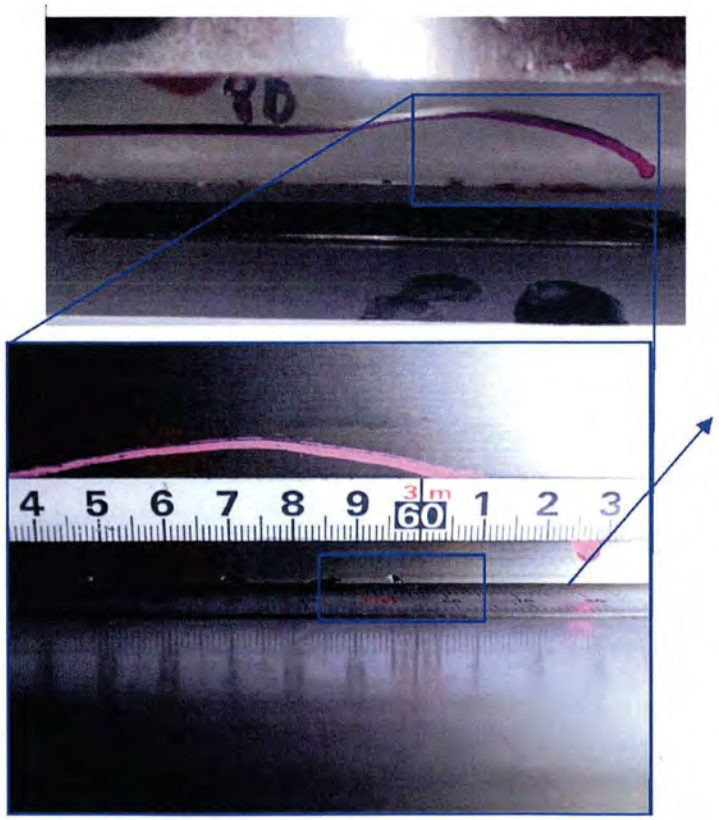
# Sample B-7

**Linear indication:** Burr at machining surface

Inspection:Unit5 Jun. 2022

| Item ID Number | | Indication | | | | |
|---|---|---|---|---|---|---|
| | Feet | Type | Size | Evaluation | Lo Rule Number | Remarks |
| 86 End | 63.05 | Linear | 8" Total | Reject | 4 | Intermittent indication Parking ledge corner |






Observation with microscope

Linear indication
Burr at machining surface.
Inclusions that existed inside the base material became near the surface layer due to machining.
Not progressive

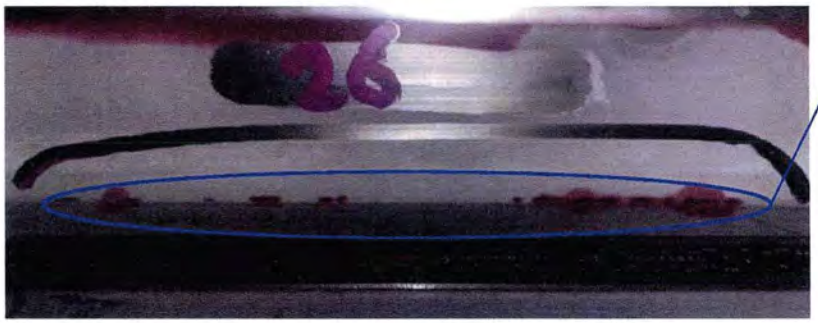
 

# Sample C-1

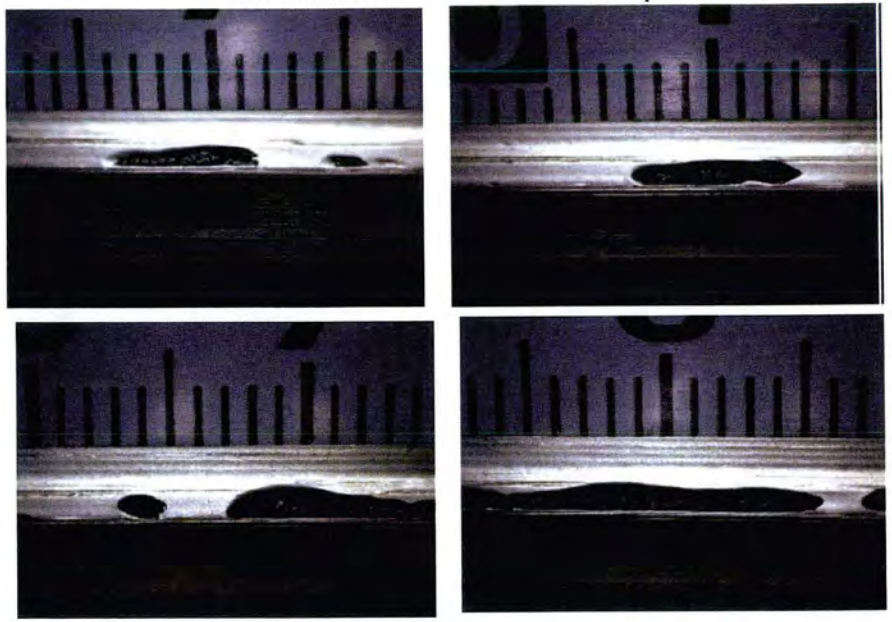
**Linear indication:** Ummelted portion of weld

Inspection:Unit5 Jun. 2022

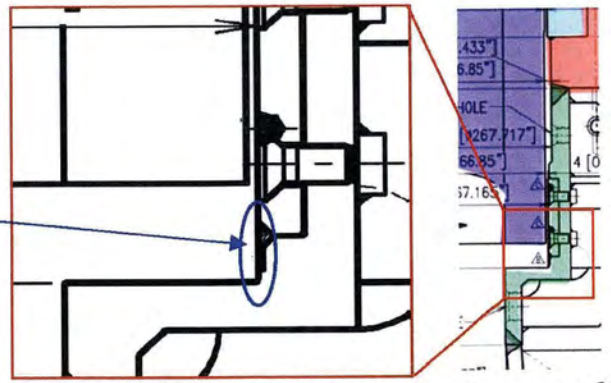
| Item ID Number | | Indication | | | | |
|---|---|---|---|---|---|---|
| | Feet | Type | Size | Evaluation | Lo Rule Number | Remarks |
| 26 | 15.68 | Linear | 5.5" | Reject | 4 | Intermittent indication Parking ledge corner |




Observation with microscope scale : mm



Linear indication
Ummelted portion of the weld below the lower seal liner.
There flaws do not impair the basic DRE requirement.
No need to repair



# Sample C-2

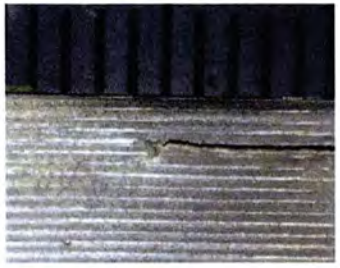
**Linear indication:** Structural gap between LSL & DRE

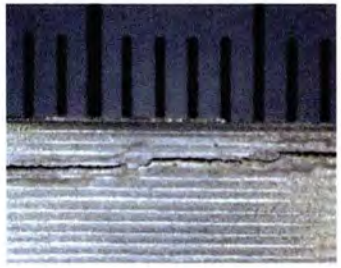
Inspection:Unit5 Jun. 2022

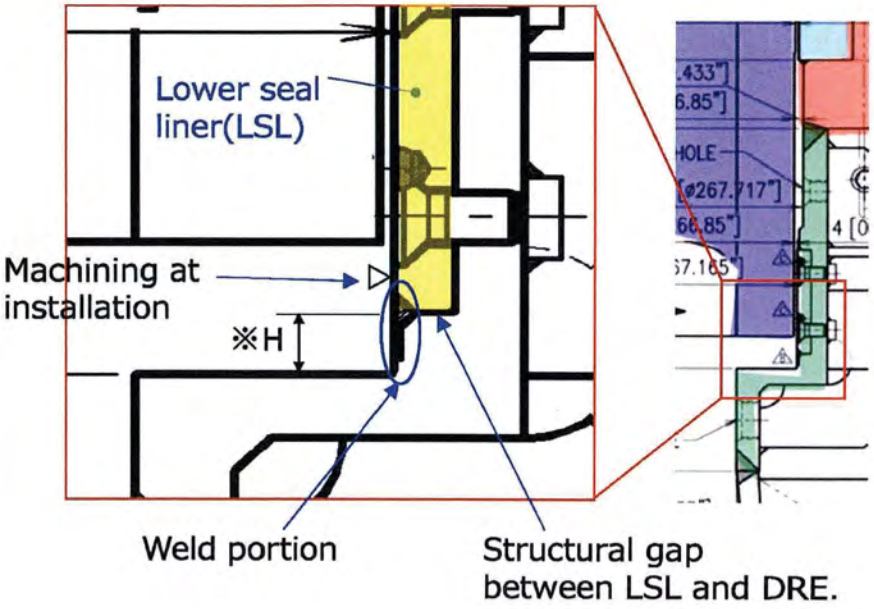
| Item ID Number | | Indication | | | | |
|---|---|---|---|---|---|---|
| | Feet | Type | Size | Evaluation | Lo Rule Number | Remarks |
| 23 | 12.99 | Linear | 7.5" | Reject | 4 | Upper Vertical Plate/Propagating |


※ Actual dimension "H" was not constant because installation tolerance of DRE.

Observation with microscope scale :mm








Linear indication

Weld portion below LSL was almost removed by machining at installation.
Structural gap between LSL & DRE was exposed due to wear.
There flaws do not impair the basic DRE requirement.
No need to repair

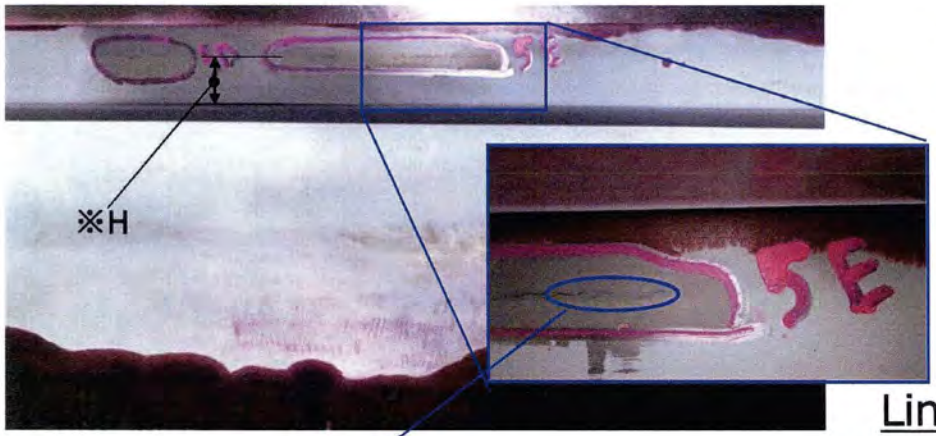
 

# Sample C-3

**Linear indication:** Structural gap between LSL & DRE

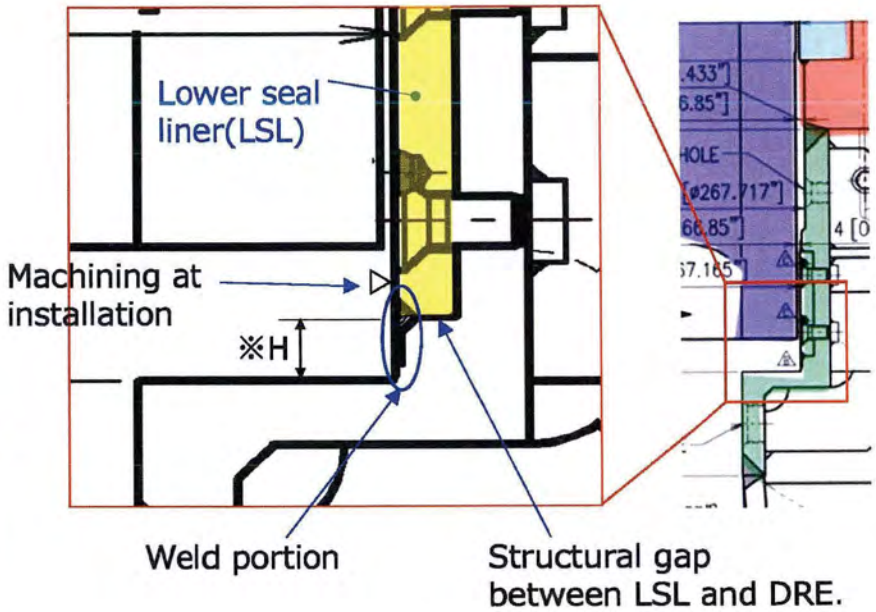
Inspection:Unit6 Jun. 2022

| Indication Number | Location | | | Evaluation | Lo Rule Number | Remarks |
|---|---|---|---|---|---|---|
| | Feet | Type | Size | | | |
| 5E | 15.20 | Linear | 6" | Reject | 4 | Upper Vertical Plate Intermitted/propagrating |




Observation with microscope

※ Actual dimension "H" was not constant because installation tolerance of DRE.




Linear indication

Weld portion below LSL was almost removed by machining at installation.
Structural gap between LSL & DRE was exposed due to wear.
There flaws do not impair the basic DRE requirement.
No need to repair.

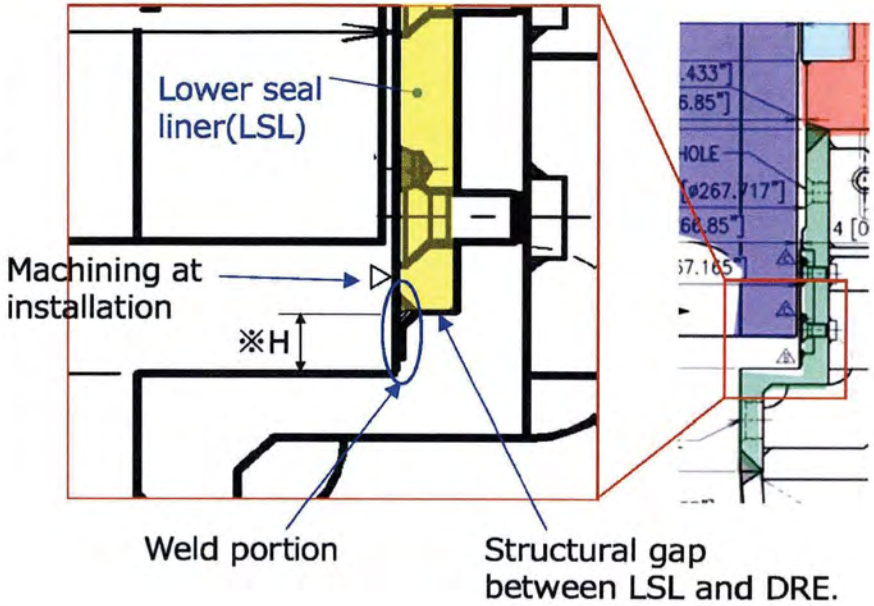
# Sample C-4

**Linear indication:** Structural gap between LSL & DRE

Inspection:Unit1 Apr. 2022

| Item ID Number | Welder ID | Indication | | | | Evaluation | Lo Rule No. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | No. | Location | Type | Size | | | |
| 2 | N/A | N/A | 3.09' | Linear | .500" | Reject | 4 | Upper Vertical |


※ Actual dimension "H" was not constant because installation tolerance of DRE.




Linear indication

Weld portion below LSL was almost removed by machining at installation.

Structural gap between LSL & DRE was exposed due to wear.

There flaws do not impair the basic DRE requirement.

No need to repair.

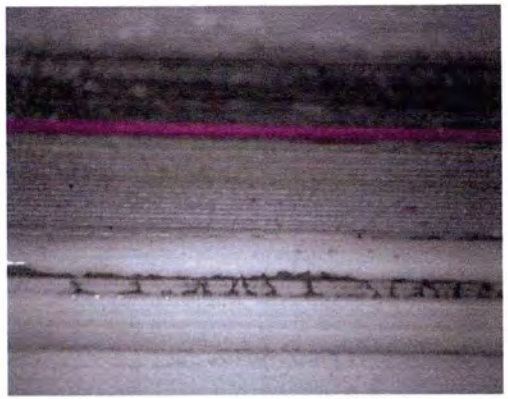
# Sample D-1

**Linear indication:** No obvious defect

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 7A | * | 8 | Linear | 2.0" | REJECT | 2022 | Upper Vertical Plate |


Observation with microscope



Linear indication
No obvious defect was found by the observation with microscope.

It seems that the PT penetrant was left unwiped.

# Sample D-2

**Linear indication:** No obvious defect on weld bead

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 66C | * | 38.00 | Linear | 10"+ | REJECT | 2022 | Parking ledge inner corner. |


Observation with microscope

Linear indication

No obvious defect was found by the observation with microscope.

It seems that the PT penetrant was left unwiped.

 20

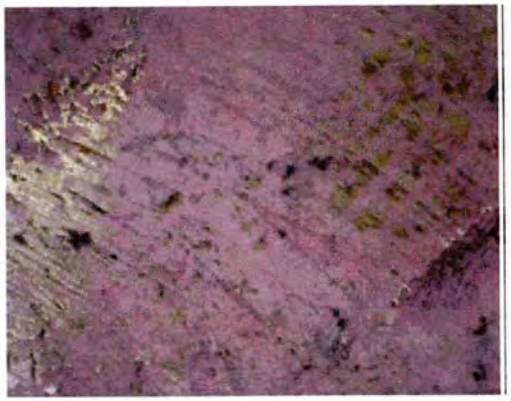
# Sample D-3

**Linear indication:** No obvious defect

Inspection:Unit2 Apr. 2022

| Item ID Number | Location | Feet around | Type | Size | Evaluation | Outage | Remarks |
|---|---|---|---|---|---|---|---|
| 31 | * | 9.50 | Linear | * | REJECT | 2019 | Lower vertical plate. |

Observation with microscope



Reference value
1mm(参考値)

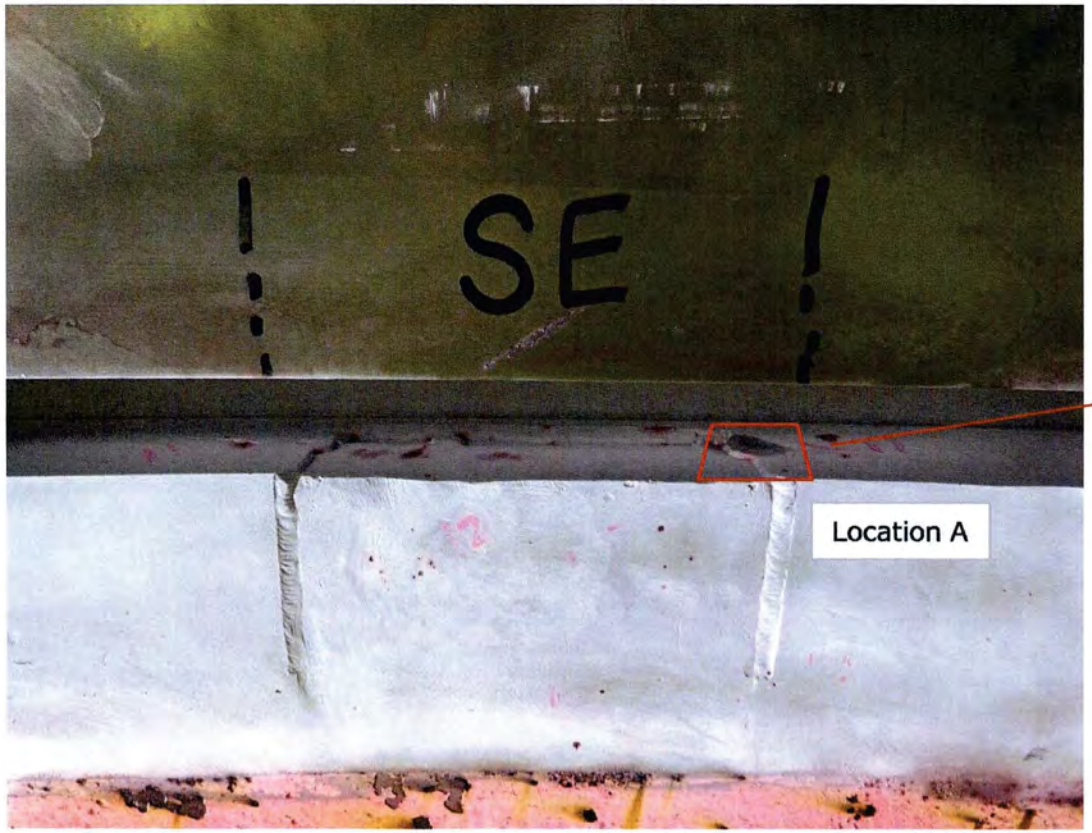
Linear indication
No obvious defect was found by the observation with microscope.

It seems that the PT penetrant was left unwiped.

# Unit 5 DRE water bleeding from pocket cover

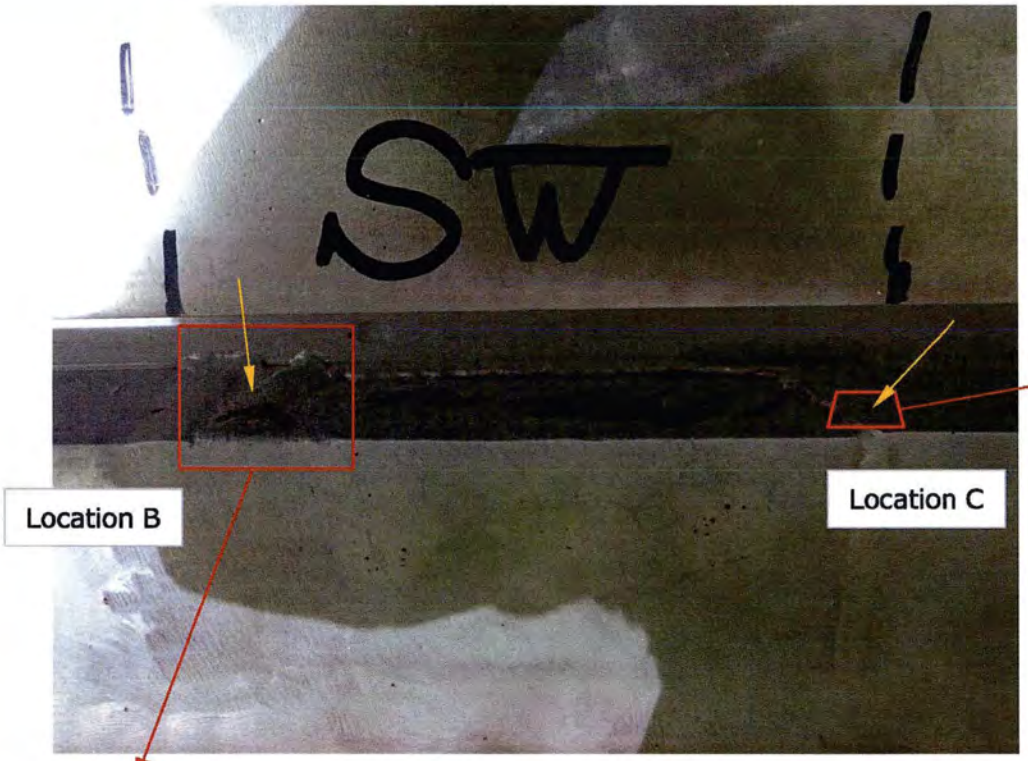
Pocket "SE"



# Unit 5 DRE water bleeding from pocket cover

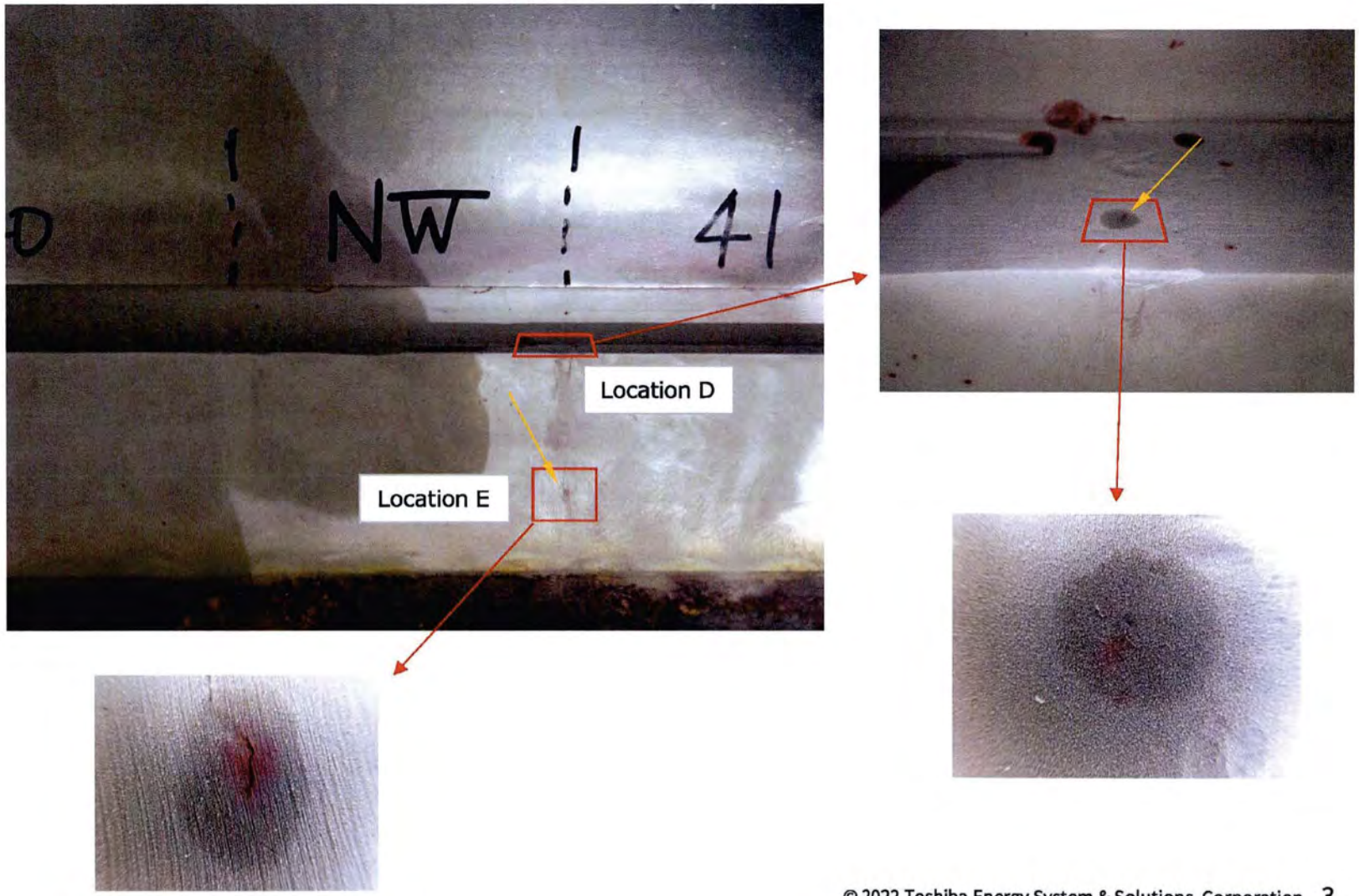
Pocket "SW"



# Unit 5 DRE water bleeding from pocket cover

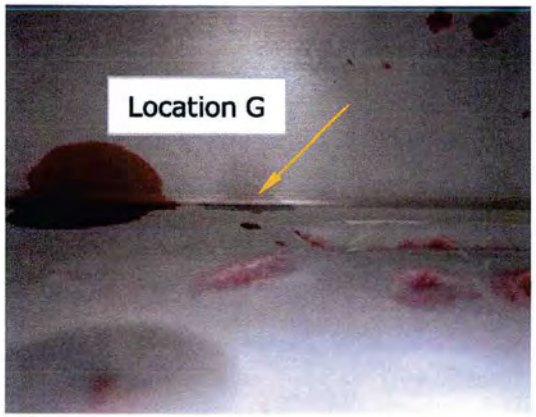
Pocket "NW"

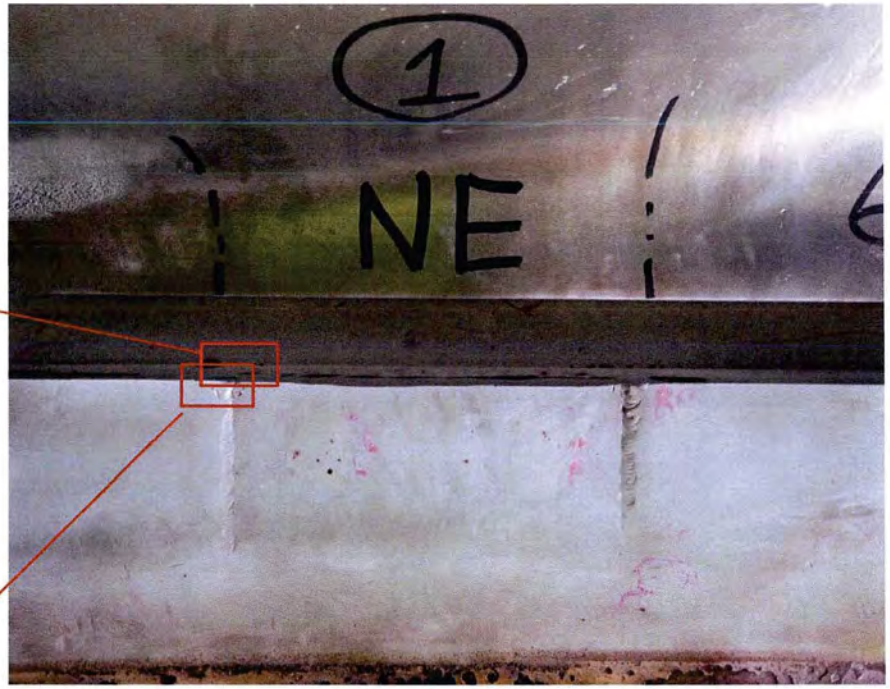


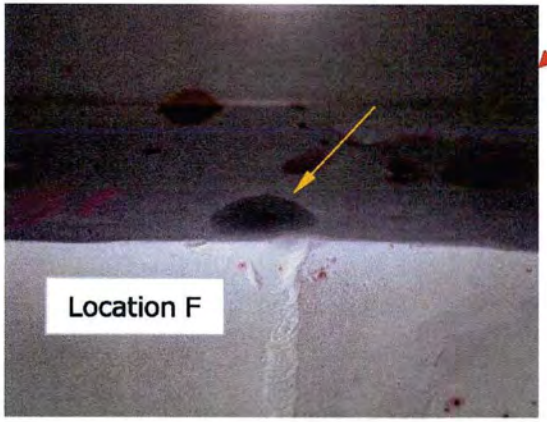

 

# Unit 5 DRE water bleeding from pocket cover

Pocket "NE"



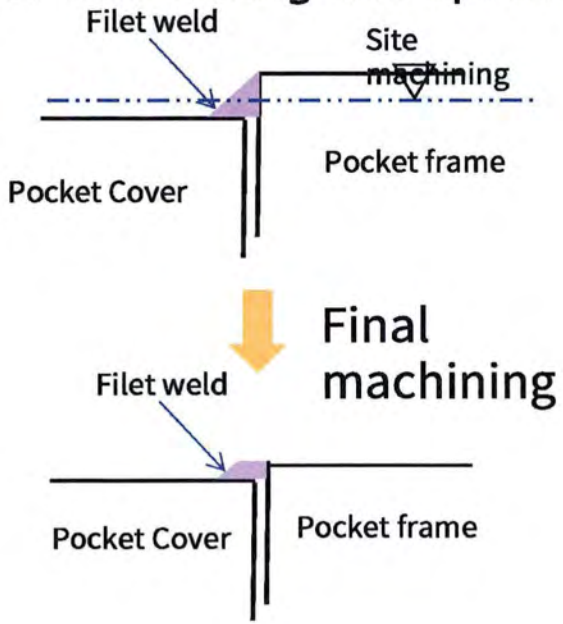



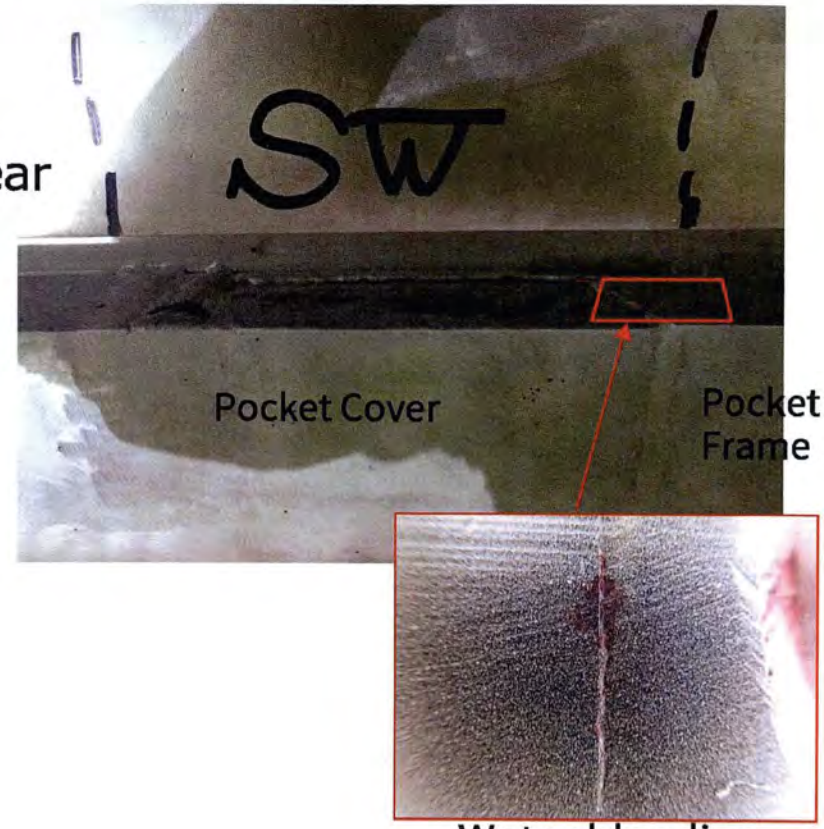

 

# Unit 5 DRE water bleeding from pocket cover

## Cause of water bleeding

Most of the filet welds were removed when machining after installation.
Thin weld portion was penetrated due to wear and tear during the operation.




Water bleeding (View from the top)

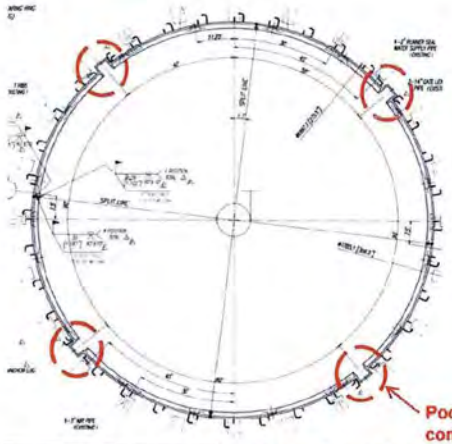
## Repair of water bleeding portion

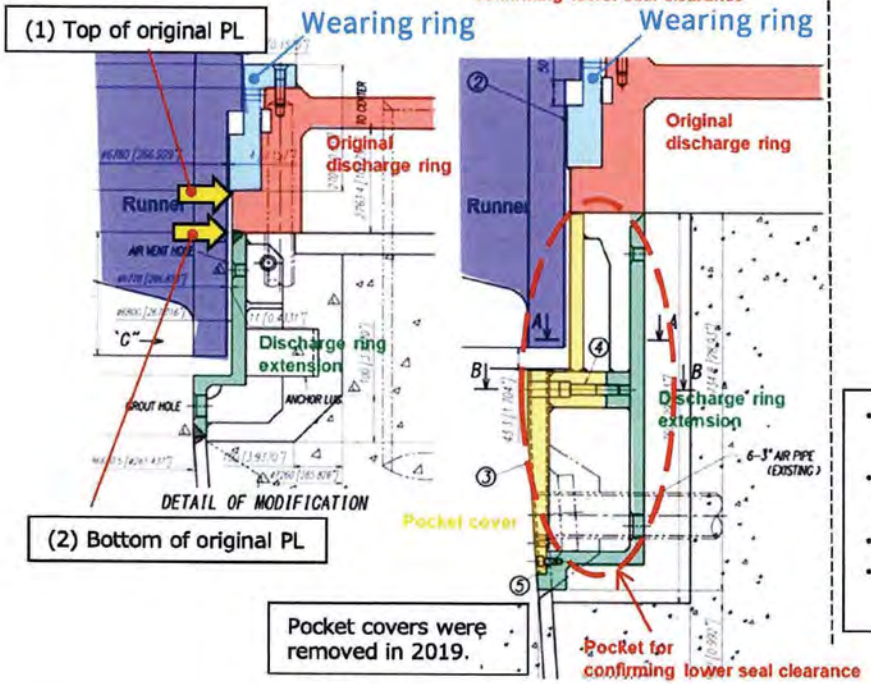
Excavate the water bleeding portion, weld the excavated area until the required thickness.

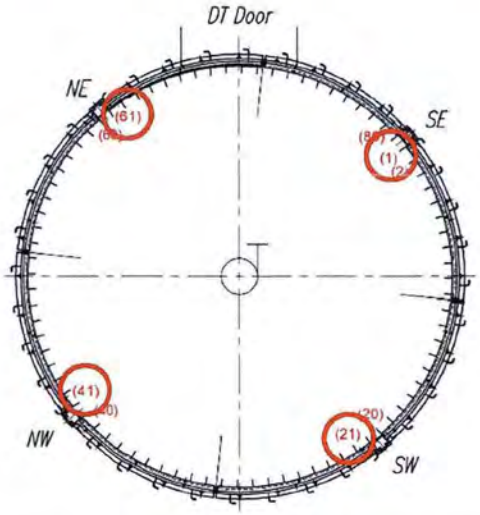
 

# DR Corrosion Inspection Result (Unit 2, 2022)

## Unit 2 (1st unit)



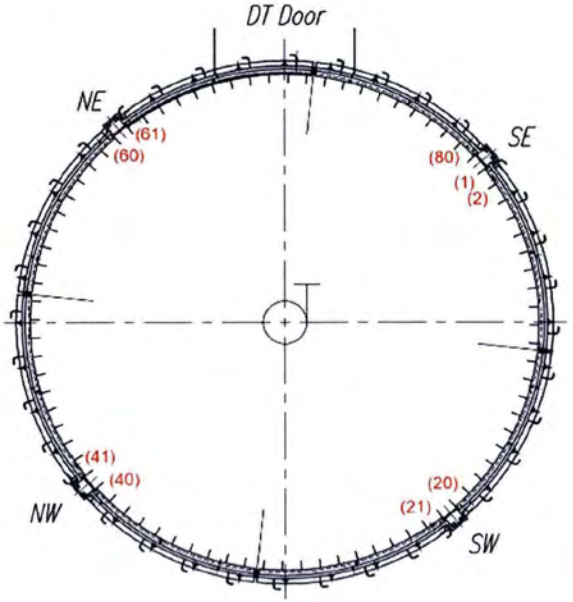

| Pocket Cover | Depth around lower part of the original PL corrosion (mm) |
|---|---|
| SE (1) | 16 |
| SW (21) | 13 |
| NW (41) | 3-4 |
| NE (61) | 19 |

- The original PL (parking ledge) was divided into 84 blocks with a circumference of 250 mm and the original PL condition was checked.
- In the lower end of the original PL, corrosion was confirmed around 3 of the 4 runner gap inspection windows. The maximum depth exceeds 20 mm.
- No additional paint in 2021 remains on the corroded area.
- The original PL near the filet weld of wearing ring was corroded not only near the inspection pocket but also at multiple locations.

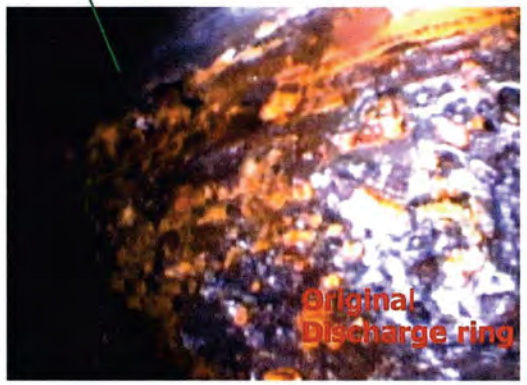
 

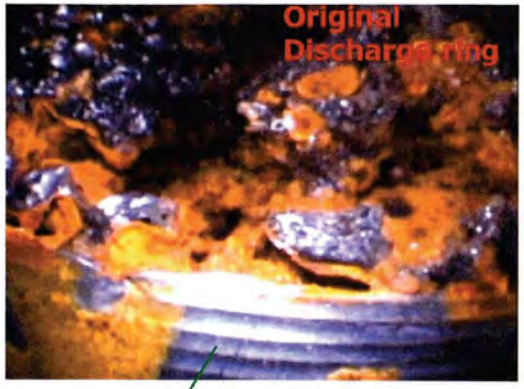
# DR Corrosion Inspection Result (Unit 2, 2022)

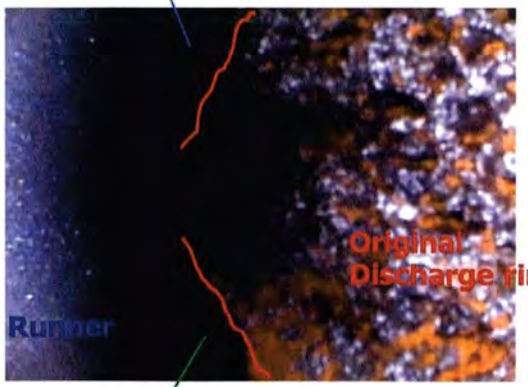
Unit 2 (1st unit)

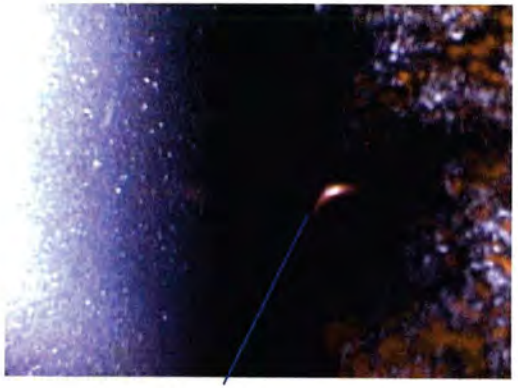



| Pocket Cover | Depth around lower part of the original PL corrosion (mm) |
|---|---|
| SE (1) | 16 |
| SW (21) | 13 |
| NW (41) | 3-4 |
| NE (61) | 19 |



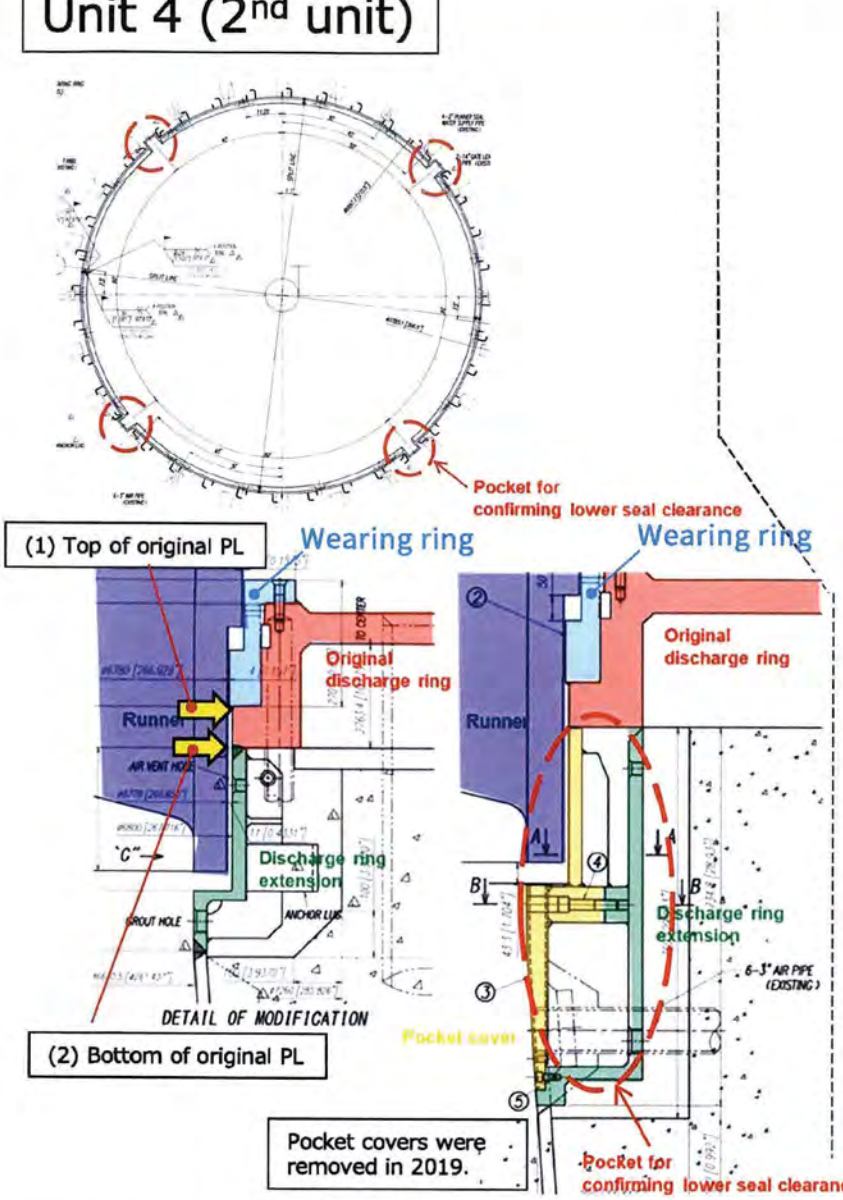



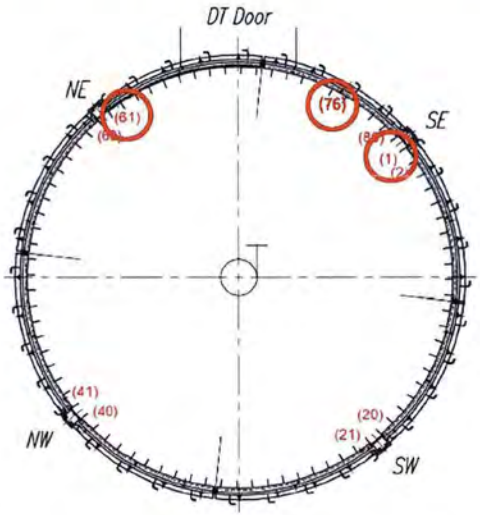



# DR Corrosion Inspection Result (Unit 4, 2022)

Unit 4 (2nd unit)



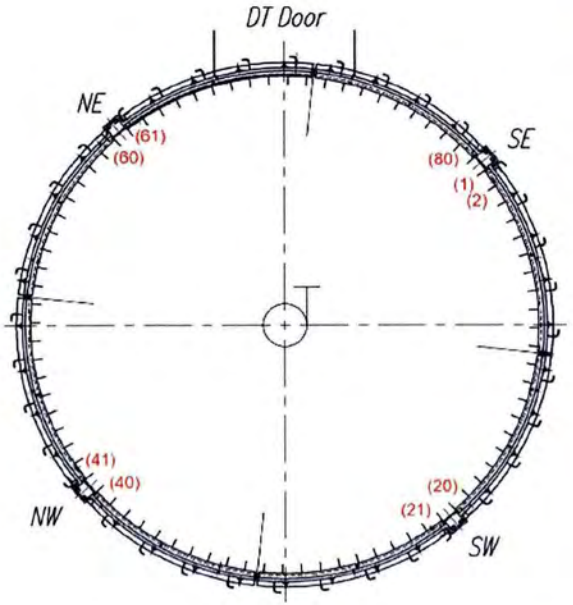

| Location | Depth around lower part of the original PL corrosion (mm) |
|---|---|
| 1 | 20 |
| 61 | 20 |
| 76 | 15 |

- The original PL (parking ledge) was divided into 84 blocks with a circumference of 250 mm and the original PL condition was checked.
- In the lower end of the original PL, corrosion was confirmed around 3 of the 4 runner gap inspection windows. The maximum depth exceeds 20 mm.
- No additional paint in 2021 remains on the corroded area.
- The original PL near the wearing ring fillet was corroded not only near the inspection pocket but also at multiple locations.

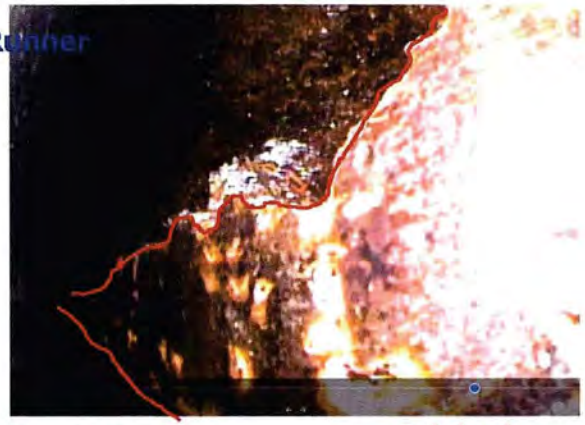
# DR Corrosion Inspection Result (Unit 4, 2022)

Unit 4 (2nd unit)

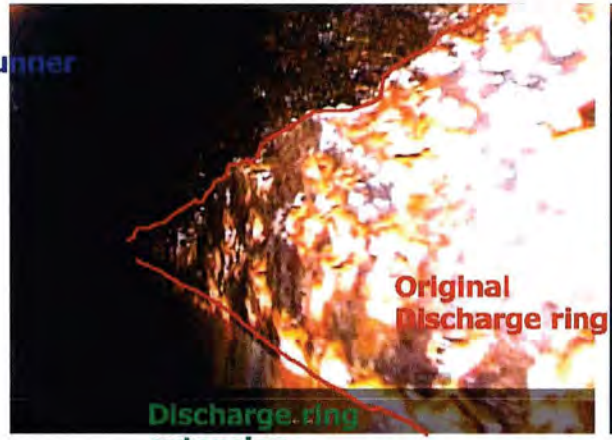



| Location | Lower part of the original PL corrosion depth measurement value (mm) |
|---|---|
| 1 | 20 |
| 61 | 20 |
| 76 | 15 |

No.1




No.61

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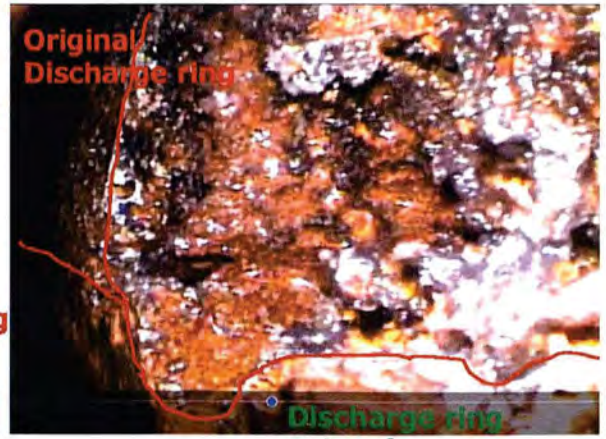
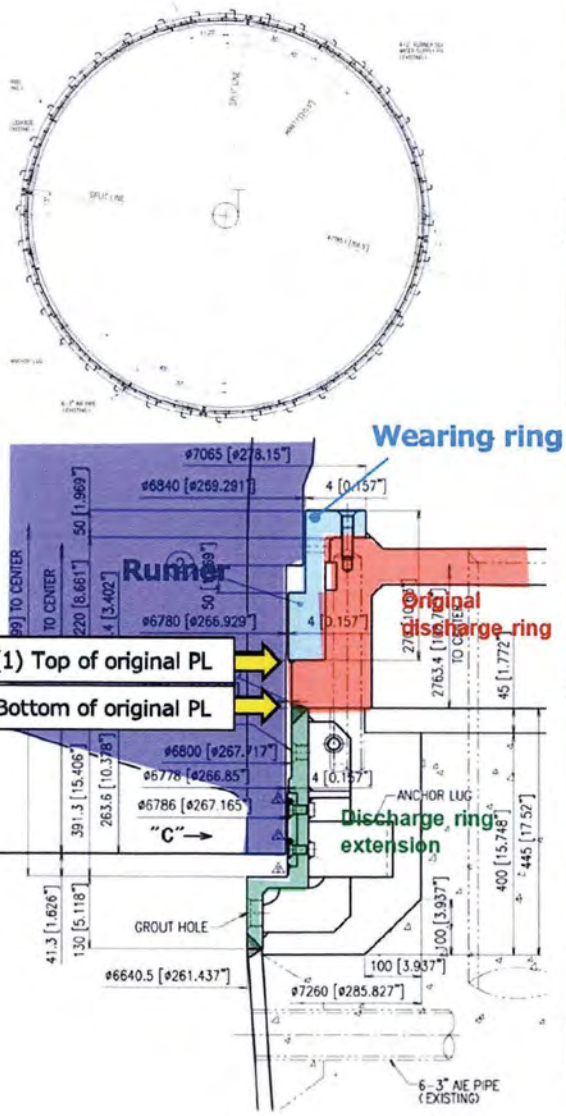


# DR Corrosion Inspection Result (Unit 5, 2022)

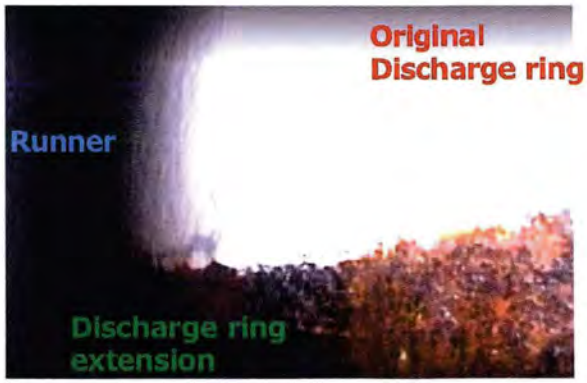
## Unit 5 (3rd unit)




- Painting remains on the surface of the existing PL almost all around.
- No significant corrosion is confirmed even in the part where the paint is peeled off.

(1) Top of original PL

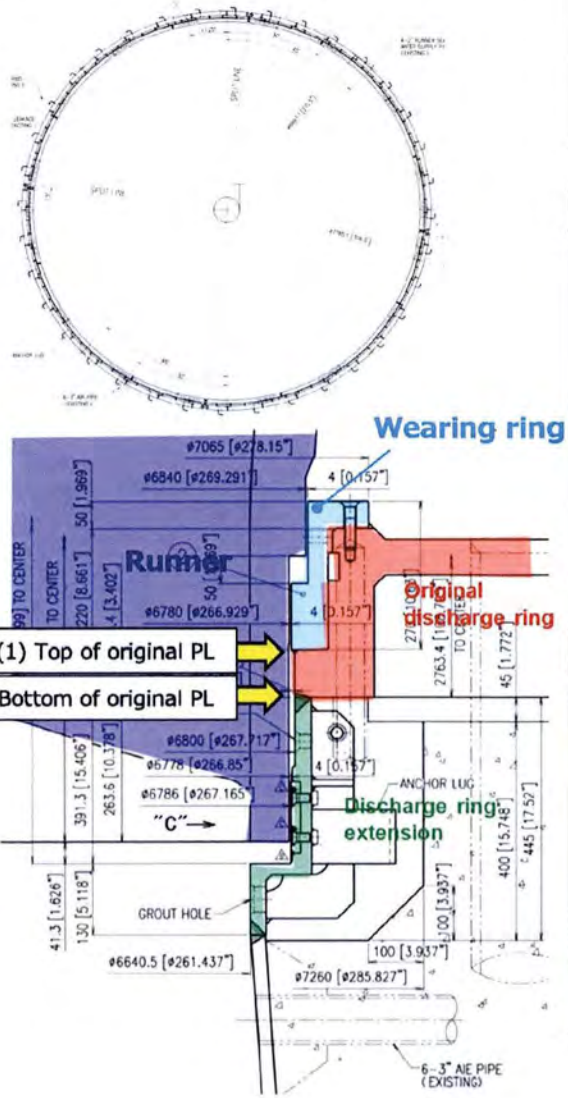

(2) Bottom of original PL

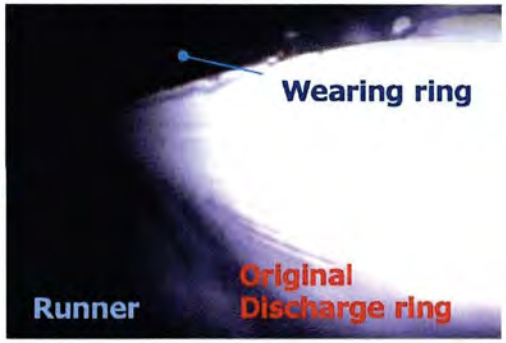
# DR Corrosion Inspection Result (Unit 6, 2022)

Unit 6 (4th unit)

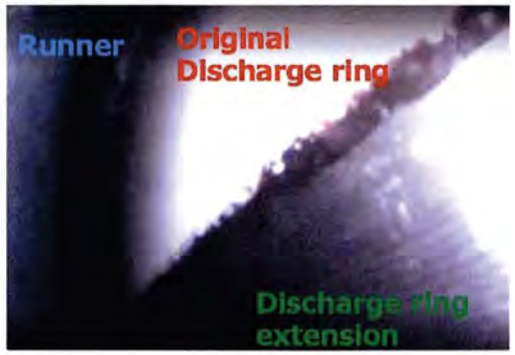


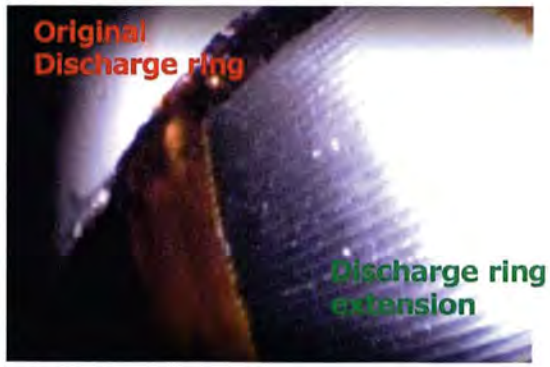

- Painting remains on the surface of the existing PL almost all around.
- No significant corrosion is confirmed even in the part where the paint is peeled off.

(1) Top of original PL




(2) Bottom of original PL

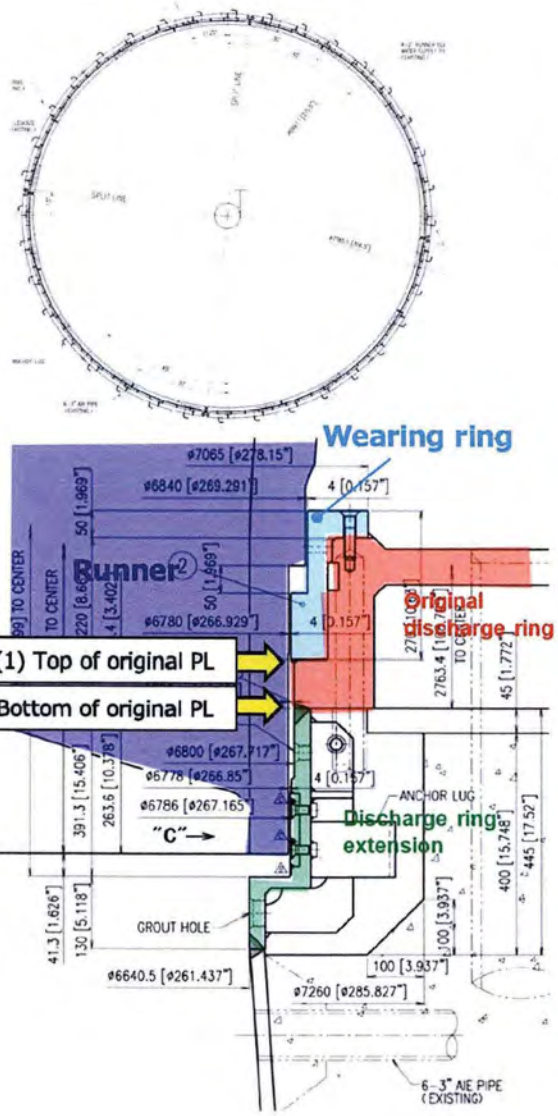


# DR Corrosion Inspection Result (Unit 1, 2022)

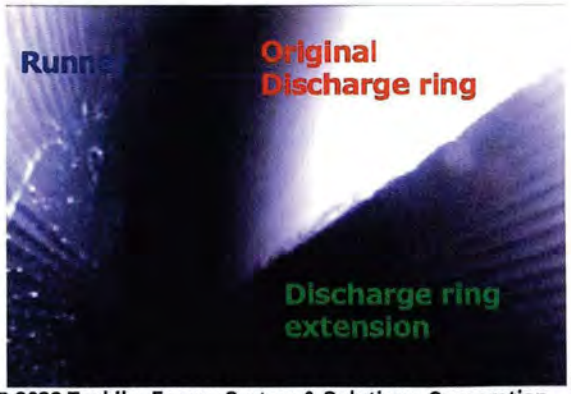
## Unit 1 (5th unit)




- Painting remains on the surface of the existing PL almost all around.
- No significant corrosion is confirmed even in the part where the paint is peeled off.

(1) Top of original PL


(2) Bottom of original PL

TOSHIBA

***Consumers Energy Company***
***Ludington Pumped Storage Plant***

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# *Procedure for jacking up/down of rotor*

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東芝エネルギーシステムズ株式会社
TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORPORATION

**TOSHIBA**

PRC K2022P0315-a

**要領書** PROCEDURE



名称 TITLE

***Procedure for jacking up/down of rotor***

| | | | |
|---|---|---|---|
| 客先名 | CUSTOMER | : | Consumers Energy Company |
| 系統機器 | EQ/SYS. | : | |
| 製番 | JOB | : | |
| プラント | PROJECT | : | XULU |

| | | | | |
|---|---|---|---|---|
| 社内配付先 DISTRIBUTION | (水力 E) | | 発行部課名 ISSUED BY<br>製造技術部<br>発電機製造技術グループ<br>MANUFACTURING ENGINEERING DEPT.<br>GENERATOR ENGINEERING GROUP | 承 認 APPROVED BY<br>*T.Tsukamoto*<br>*Oct.07.2022* |
| | (TAES) | | | |
| (水 SX) | | | | 調 査 REVIEWED BY<br>*S.Tanimoto*<br>*Oct.07.2022* |
| (水発 D) | | | | 担 当 PREPARED BY<br>*S.Takaki*<br>*Oct.07.2022* |
| (水発組) | | | | |

東芝エネルギーシステムズ株式会社 京浜事業所
TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORPORATION Keihin Product Operations

This document is used for jacking up/down of rotor (including main shaft & runner).

1. Rotor weight to be jacked up/down
   Table 1 shows the rotor weight to be jacked up/down.

Table1 : Rotor weight

| | kN | Ton |
|---|---|---|
| Rotor spider | 2267 | 231 |
| Rotor rim | 6227 | 635 |
| Rotor pole | 2209 | 225 |
| U.shaft | 157 | 16 |
| Turbine(Runner+Main shaft) | 3613 | 368 |
| Total | 14473 | 1476 |

2. Preliminary verification prior to jacking up

   2.1. Measurement
   Check clearance of "X" and "Y" at four locations. Minimum clearance must be more than 160 mils.
   (X=Runner clearance, Y=clearance between thrust runner and oil box)
   If necessary, TA, supervisor or foreman instruct to adjust unit center with using HPOS.

   2.2. Verification
   All stationary parts (e.g. cover, guide bearing, bracket, piping, wiring) which interferes by jacking up/down of rotor shall be disassembled.

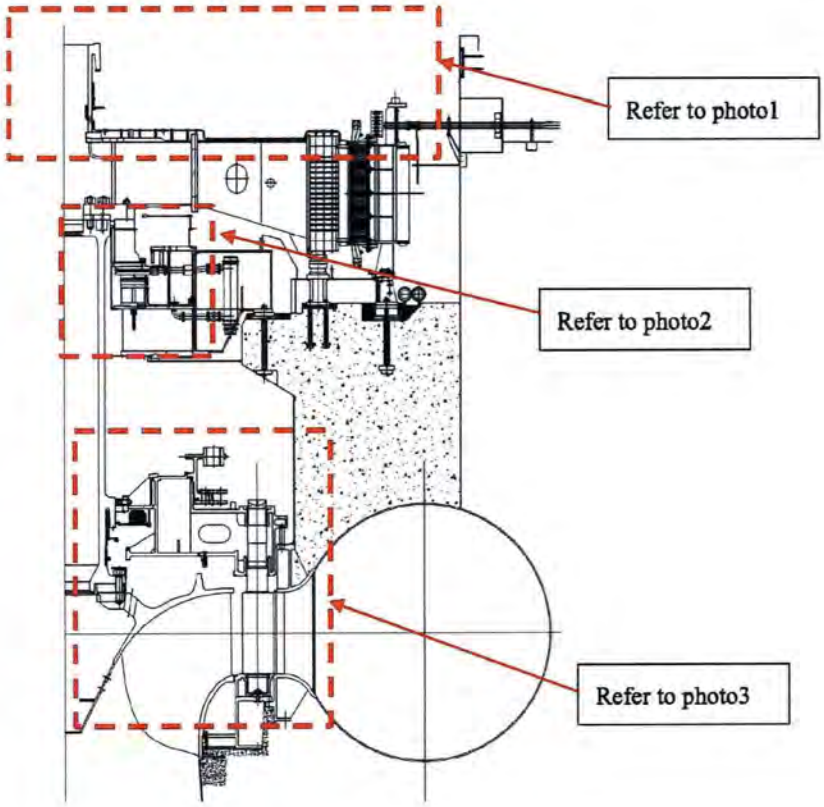



Fig.1 Outline before jacking up rotor

Photo1 Reference around upper shaft

Photo2 Reference around lower bearing

Photo3 Reference around head cover

Disassembly work prior to jacking up of rotor shall be performed in accordance with the following documents.

| | |
|---|---|
| 3GD10.01 | Remove Top Cover Roof, SSG, and Collector Brush Rigging |
| 3GD10.02 | Disassemble Upper Guide Bearing Prior to Run-out Check |
| 3GD10.03 | (Determinate the Wiring for the Upper Bracket and Top House) |
| 3GD10.04 | Field Leads Disassembly (Removal of the Field Leads and Field Cables) |
| 3GD25.01 | Remove Collector Rings and Top Cover Walls |
| 3GD25.02 | Remove Air Housing |
| 3GD30.01 | Prepare to Remove the Upper Bracket |
| 3GD30.02 | Remove Upper Bracket |
| 3GD80.01 | Disassembly within the Bearing Reservoir |
| | |
| TD05.01 | Runner Center Check |
| TD10.01 | Measure Turbine Guide Bearing Center Check and Set-up for Run-out Check |
| TD20.01 | Removal of Turbine Pit Instrumentation and Wiring |
| TD25.01 | Remove Walkways and Handrails |
| TD25.02 | Clean the Head Cover |
| TD25.03 | Remove Head Cover Piping |
| TD25.04 | Servomotor Piping |
| TD25.05 | Grease Piping and Tubing |
| TD27.02 | Remove Bearing Housing |
| TD30.01 | Separate Links and Arms |
| TD30.02 | Remove Wicket Gate Arms |
| TD35.01 | Remove Servomotor Links |

| | |
|---|---|
| TD35.03 | Remove Servomotors |
| TD40.01 | Loosen Head Cover Nuts |
| TD40.03 | Raise Head cover onto Wicket Gates |
| TBD | Jack Up Head Cover |

3. Preparation for jacking up/down of rotor

3.1. Remove brake and jacks (B&J)

Disassemble connection for the B&J at eight locations. Refer to Fig.2.
Lift up the B&J by jack bolt or crowbar.
Insert round bar under the B&J. Then, remove to next lower coil end cover from the B&J base.

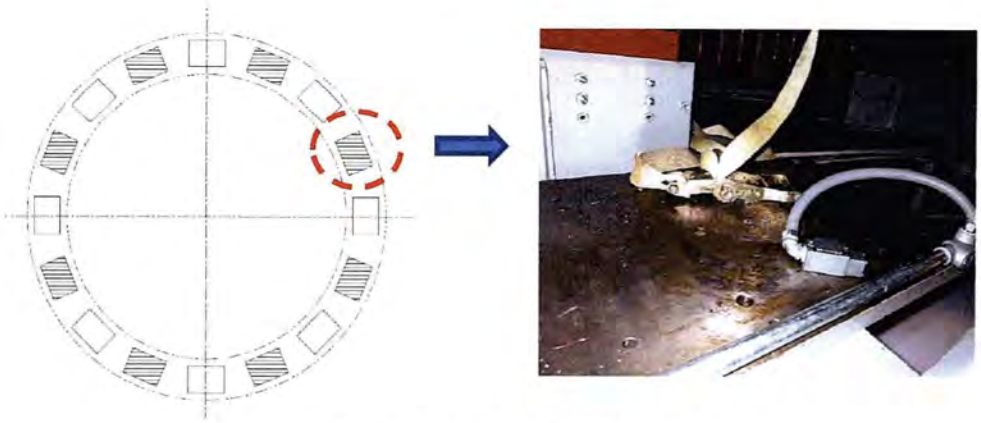


Fig.2 B&J locations to be removed

3.2. Installation of oil jacks

Install two 100ton oil jacks and spacers on each B&J base where B&J is removed.
If the oil jacks can be installed without removing B&J, this section can be ignored.

3.3. Reinforcement for brake ring

Install taper block or journal jack between rotor rim and brake to prevent brake ring deformation.
If the spacer block is located above the oil jack, it is not necessary to install taper block.

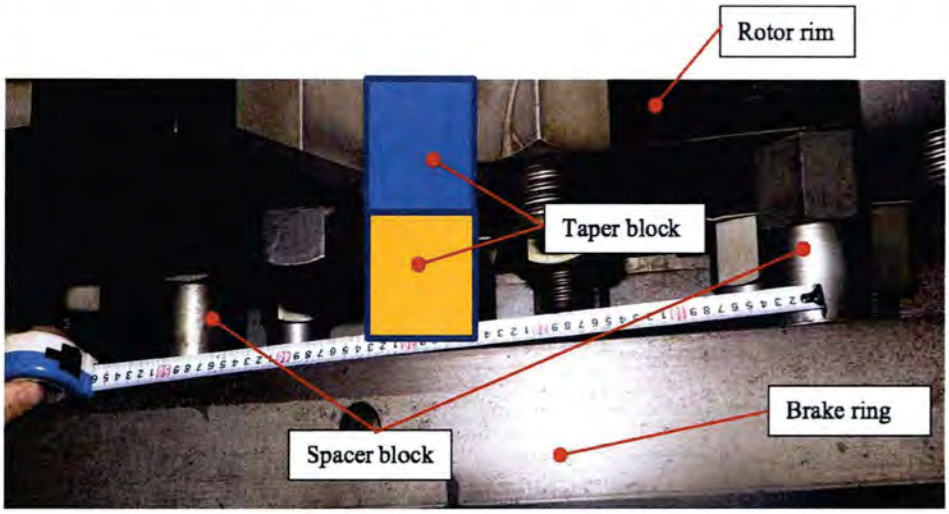



Fig.2 Prevention of deformation of brake ring

3.4. Installation of dial indicators and guide block
Dial indicators shall be installed as follows, and four guide blocks (push bolt with PTFE plate) shall be installed before jacking up work to prevent the unexpected accident.

A: Brake ring (8 locations: V)
B: Thrust collar (2 locations: R)
C: Thrust runner (2 locations: V)
D: Main shaft (2 locations: R)

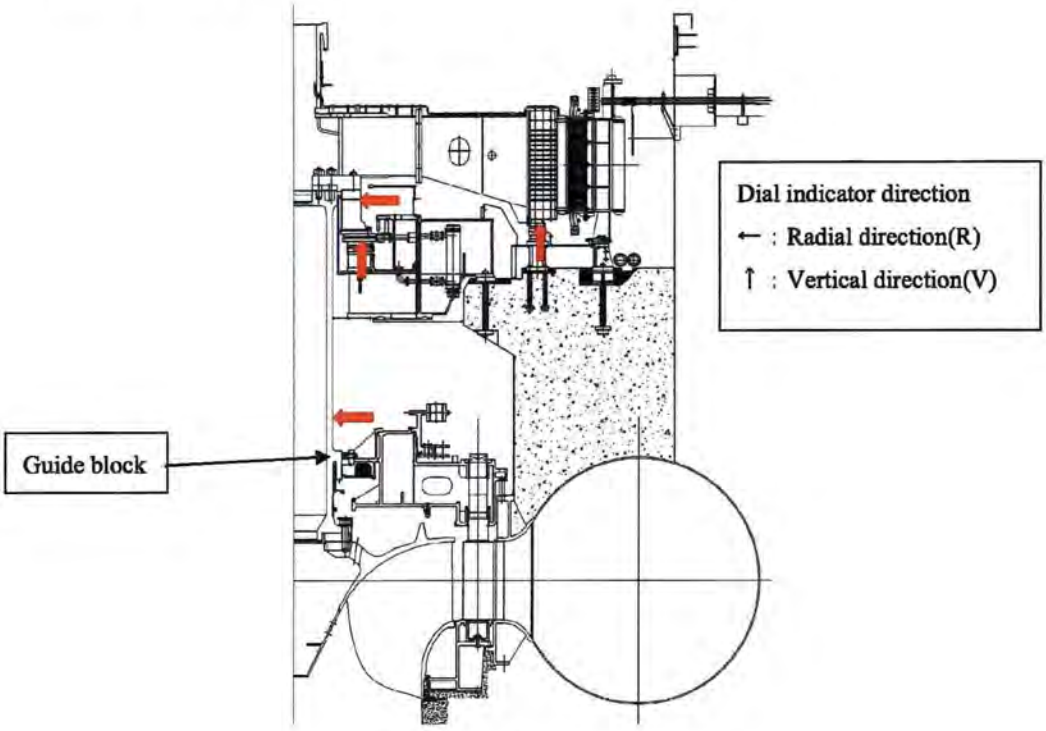



Fig.3 Dial indicator position

4. Jacking up/down of rotor
This section is to be replaced with the Subcontractor's procedure once the order is placed.

4.1. Jacking up of rotor by oil jacks

4.1.1 Jack up the rotor slowly 40 mils at a time with 100ton jacks, and monitor dial indicators("A") to keep level of rotor.

4.1.2 After dial indicator "C" shows movement of rotor, stop to jack up rotor.
Then, clearance of "X" and "Y" in four locations. Minimum gap must be over 120 mils.
If minimum gap is less than 120 mils, TA, supervisor or foreman direct the order of jacking up.

4.1.3 Jack up the rotor slowly 40 mils at a time with 100ton jacks until stroke of oil jack reach approximately 4 inches.

4.1.4 Put spacer on each B&J.
After then, release pressure of oil jacks to be loaded on B&J temporarily.

4.1.5 Set spacer under oil jack.

4.1.6 Repeat 4.1.3~4.1.5. until rotor is jacked up target value.
Finally, rotor is loaded on eight B&Js. (And rotor is supported with oil jacks subsidiary.)

<Caution>
This work must be performed carefully during monitor dial indicators.
It is necessary to reset dial indicator because of differential of diameter or limit of dial indicator.
When dial indicator are reset, must be stopped to do jacking up.
If anything happens, report to TA, Supervisor or foreman.

4.2. Jacking down of rotor by oil jacks

4.2.1 Check clearance of "X" in four locations. Minimum clearance shall be over 120 mils.
(X=Runner clearance, Y=clearance between thrust runner and oil box)
If minimum gap is less than 120 mils, TA, supervisor or foreman direct the order of jacking down.

4.2.2 Verify whether all parts are not interfering with the jacking down of rotor.

4.2.3 Set dial indicators and guide blocks. (Refer to 3.4)

4.2.4 Jack up the rotor slightly with 100ton jacks during monitor dial indicator.

4.2.5 Pull out spacer on B&J.

4.2.6 Release pressure of oil jacks to be loaded on B&J.

4.2.7 Repeat 4.2.4~4.2.6.

<Caution>
This work must be performed carefully during monitor dial indicators.
It is necessary to reset dial indicator because of differential of diameter or limit of dial indicator.
When dial indicator are reset, must be stopped to do jacking down.
If anything happens, report to TA, Supervisor or foreman.

| 変更 REV. | PAGE | 変更箇所及び内容 CHANGED PLACE AND CONTENT | 承認 APPROVED | 調査 REVIEWED | 担当 PREPARED |
|---|---|---|---|---|---|
| a | - | *Initial Issue* | Written in page 2. | Written in page 2. | Written in page 2. |

**TOSHIBA**

PRC K2022P0327-b

# 要領書 PROCEDURE



名称 TITLE

REPAIR WELDING PROCEDURE for DISCHARGE RING (Unit 2, 4)



| | | | | |
|---|---|---|---|---|
| 社内配付先 DISTRIBUTION | – | – | 発行部課名 ISSUED BY<br>機器製造部<br>製造技術・生産管理グループ<br>MACHINING & WELDING DEPT.<br>MANUFACTURING ENGINEERING & PRODUCTION CONTROL GROUP | 承 認 APPROVED BY |
| | – | – | | 調 査 REVIEWED BY |
| – | – | – | | |
| – | – | – | | 担 当 PREPARED BY<br>Y. Nakabayashi<br>Oct. 29, 2024 |
| – | – | – | | |

東芝エネルギーシステムズ株式会社 京浜事業所
TOSHIBA ENERGY SYSTEMS & SOLUTIONS CORPORATION Keihin Product Operations

1 .Scope

This procedure is applied to the stainless over-lay welding work for the corroded parts of the Discharge Ring for Unit 2 and 4.

本要領書はユニット 2 及び 4 のディスチャージリングの腐食部に対するステンレス肉盛溶接作業に対して適用する。

2.Work flow

| No. | Process |
|---|---|
| 1 | Jack up completion confirmation<br>ジャッキアップ完了確認 |
| ↓ | |
| 2 | Removal of paint and rust on the inner diameter surface of the existing discharge ring<br>既設ディスチャージリング内径面の塗装及び錆の除去 |
| ↓ | |
| 3 | Visual inspection of the removed area<br>除去部の目視確認 |
| ↓ | |
| 4 | Base shaping of the removed part for welding<br>除去部の溶接下地整形 |
| ↓ | |
| 5 | Measurement before welding<br>溶接前寸法確認 |
| ↓ | |
| 6 | Pocket cover installation<br>ポケットカバの据え付け |
| ↓ | |
| 7 | Stainless steel overlay welding on the inner diameter of the existing discharge ring<br>既設ディスチャージリング内径面のステンレス肉盛溶接 |
| ↓ | |
| 8 | Finishing for welding<br>溶接部の仕上げ |
| ↓ | |
| 9 | PT where welding area<br>溶接部 PT |
| ↓ | |
| 10 | Confirmation of stainless steel overlay welding amount and deformation<br>ステンレス肉盛溶接量及び変形量の確認 |

3. Jack up completion confirmation
ジャッキアップ完了確認

1) Confirm that the runner is jacked up by about 400mm.
ランナが 400 ㎜程度ジャッキアップされたことを確認する。

2) Figure 3.1 shows the positional relationship of the equipment after jacking up.
ジャッキアップ後の機器の位置関係を図 3.1 に示す。

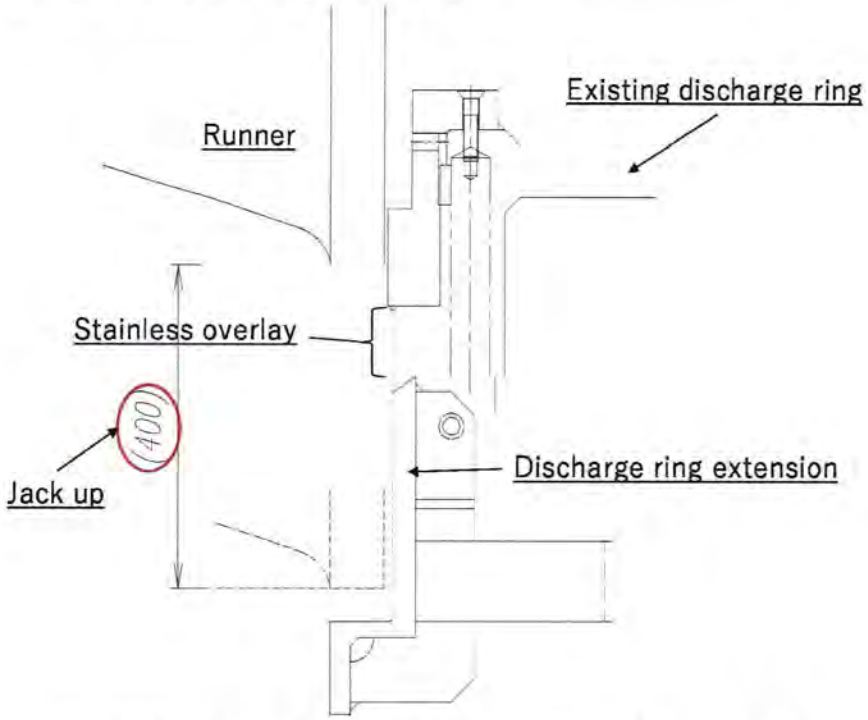



Fig.3.1 Positional relationship of the equipment after jacking up

4. Removal of paint and rust on the inner diameter surface of the existing discharge ring
既設ディスチャージリング内径面の塗装及び錆の除去

1) Cover the non-overlay surface of the discharge ring and the bottom of the runner.
ディスチャージリングの肉盛しない面及びランナ底部を養生する。

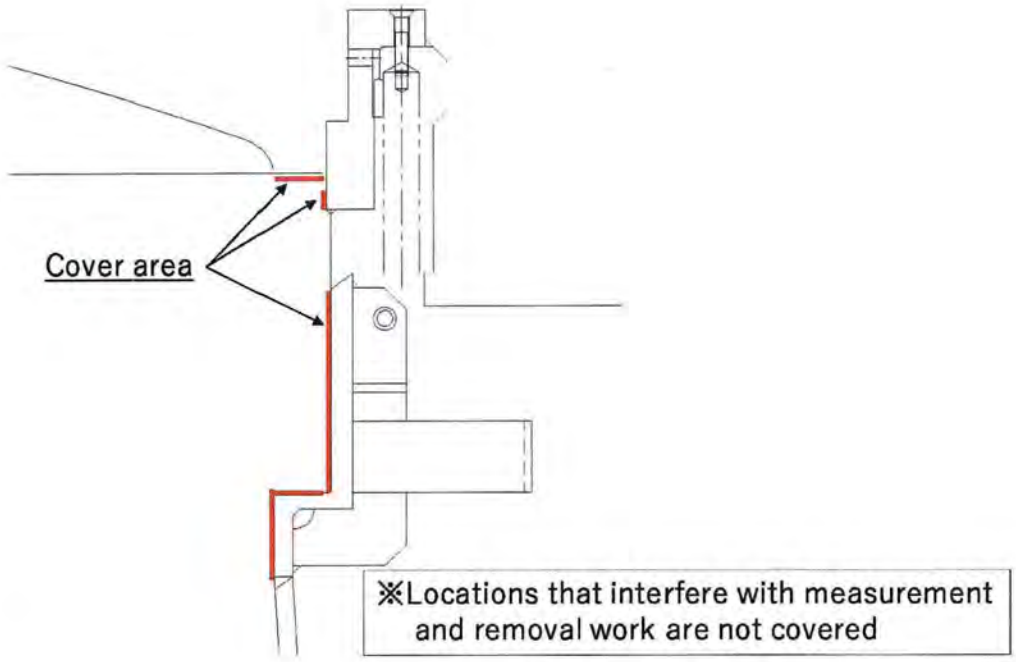



Fig.4.1 Cover area before removal

2) Remove the remaining coating film on the surface to be overlaid with stainless steel in Fig. 3.1.
図 3.1 のステンレス肉盛対象面の残存した塗膜を除去する。

3) The actual removal range is marked by checking the actual product. The maximum removal depth is 20mm, and even if rust remains beyond that, welding work can be started.
実際の除去範囲は現物を確認してマーキングする。除去深さは最大で 20 ㎜とし、それ以上は錆部が残存していても溶接作業に移行する。

4) In addition, even if there are fine unevenness, if welding is possible, the welding operation is started without smooth finishing.
また、微細な凹凸があっても、溶接が可能であれば平滑に仕上げずに溶接作業に移行する。

5) Use an electric or air tool such as a grinder for removal.
除去にはグラインダなどの電動またはエアーツールを使用する。

5. Visual inspection of the removed parts
除去部の目視確認

1)Check if deeply removed area is penetrated.
深く除去した箇所が貫通しているか否か確認する。

6. Base shaping of the removed area for welding

除去部の溶接下地整形

1) The base metal is shaped so that the removed area can be welded.

除去部に対して、溶接ができるように下地を整形する。

2) After confirming the actual product, the shape is determined in consultation with welding engineer.

形状は現物を確認した上で溶接技術者と相談して決定する。

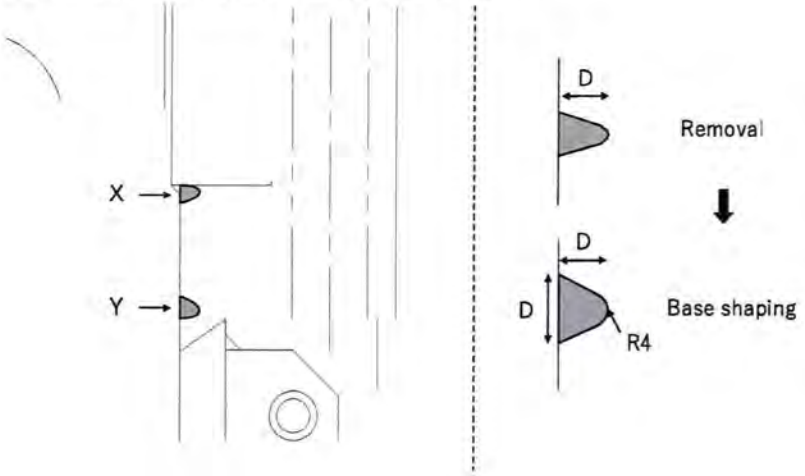



Fig.6.1 Example of base shaping

7. Measurement before welding

溶接前寸法確認

1) Measure and record the runner gap (A) in Fig. 7.1 to check the dimensional change before and after welding.

溶接前後の寸法変化を確認するために、図 7.1 のランナギャップ（A）を測定し、記録する。

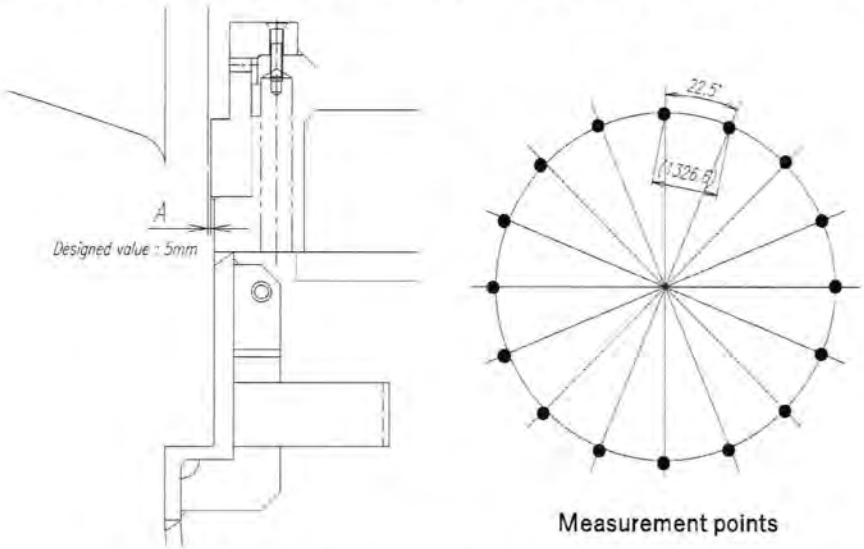



Fig.7.1 Measurement for Runner gap

2) Measurement of the runner gap is performed at 16 equipartitions. Mark the measurement point so that it can be seen even after welding.
ランナギャップの測定は 16 等配で行う。測定箇所は溶接後もわかるようにマークしておく。

3) To confirm the amount of stainless steel overlay welding, measure and record the step between wearing ring and discharge ring (B in Fig. 7.2).
ステンレス肉盛溶接量の確認のために、Wearing ring とディスチャージリングの段差（図 7.2 の B）を測定し、記録する。

4) Step measurement is performed at 48 equal divisions (about 445 mm).
Mark the measurement point so that it can be seen even after welding.
段差測定は 48 等分(約 445mm)で行う。測定箇所は溶接後もわかるようにマークしておく。

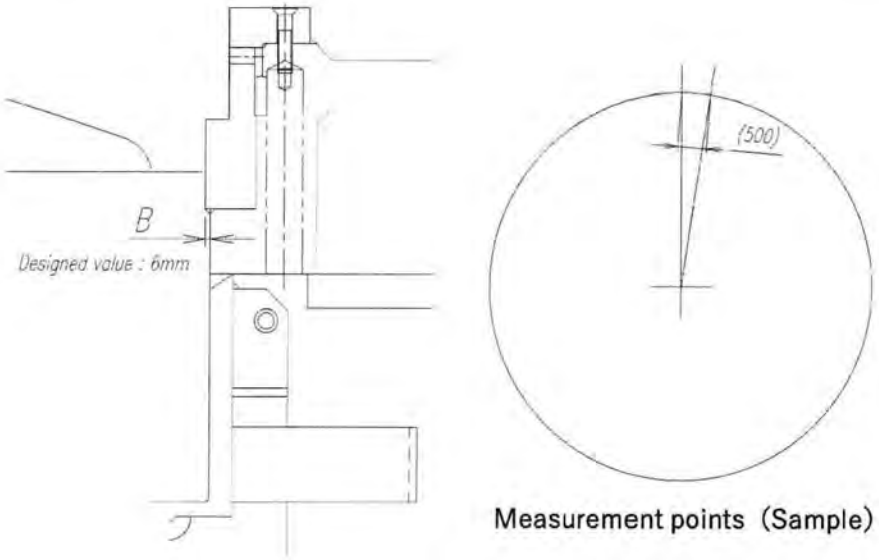



Fig.7.2 Measurement of step between wearing ring and discharge ring

b 8. Pocket cover installation
ポケットカバの据え付け

1) The pocket cover shall be installed in accordance with 1KQ008802.
ポケットカバの挿入は 1KQ008802 に従い、施工します。

2) Table 8.1 applies to welding materials.
溶接材料は表 8.1 を適用します。

3) Table 8.2 applies to welding conditions.
溶接条件は表 8.2 を適用します。

9. Stainless steel overlay welding on the inner diameter surface of the existing discharge ring
既設ディスチャージリング内径面のステンレス肉盛溶接

1) The following types of stainless steel overlay welding are performed so that the carbon steel part is not exposed to the running water.
①Inside diameter of the existing discharge ring (stainless overlay area in Fig. 3.1)
炭素鋼部位を流水部に露出させないように以下のステンレス肉盛溶接を行う。
①既設ディチャージリング内径面（図 3.1 の肉盛溶接対象部）

2) The welding process is FCAW/GMAW or TIG depending on the situation.
溶接方法は FCAW/GMAW または TIG を状況に合わせて使い分ける。

3) All welding materials use SUS309L.
溶接材料は全て SUS309L を使用する。

Table 8.1 Welding Material

| Welding Process | AWS | Sample Filler Metal |
|---|---|---|
| GTAW | A5.9 ER309L | TG-S309L |
| FCAW/GMAW | A5.22 E309LT0-1 / A5.22 E309T0-1 | DW-309L |

※It can be used if it is an equivalent standard material.

4) Table 8.2 applies to the welding conditions.
溶接条件は表 8.2 を適用する

Table 8.2 Welding Condition

| | FCAW/GMAW | | | GTAW | GTAW |
|---|---|---|---|---|---|
| | φ1.2 | φ1.4 | φ1.6 | φ2.0 | φ2.4 |
| Current(A) | 100～300 | 150～400 | 180～450 | 80～150 | 90～150 |
| Voltage(V) | 20～40 | | | 8～15 | |

5) If the depth of rust on the discharge ring is 20 mm or more after removing the rust, and if it remains at the bottom, may be put in the bottom and backfill welding may be performed from above. However, in that case, ensure a welding depth of 10 mm or more.
ディスチャージリングの錆の除去時に深さが 20 ㎜以上あり、底部に残存している場合は、底部に埋金等を入れてその上から埋め戻しの溶接を行うこともある。但しその場合は、溶接深さを 10 ㎜以上確保する。

6) For the part that contacts the wearing ring (X part in Figure 6.1), fill the part with a depth of 10 mm or more to prevent welding deformation.
Wearing ring に接触する部分（図 6.1 の X 部）については、溶接変形抑制のために除去深さ 10 ㎜以上の部分には埋金をする。

7) Before overlay welding, weld the rust-removed part to make the surface almost uniform.
However, the bead surface shall not be smoothed.
肉盛溶接の前に錆除去部の埋め戻し溶接を行い、面を概ね均一にする。但し、ビード表面の平滑仕上げは

行わない。

8) After the (7) work, perform stainless steel overlay welding on the inner diameter surface of the existing discharge ring.

7) 作業の後に既設ディスチャージリング内径面のステンレス肉盛溶接を行う。

9) In order to reduce the deformation due to overlay welding, the whole circumference is divided into a 48 -equal (about 445mm) block and the number is described on the actual product. Fig.8.1 shows an example of the welding procedure. When overlay welding the second layer, start from the block one block to the left of the one welded in the first layer and perform welding in the same order.

肉盛溶接による変形を低減させるために、全周を 48 等分(約 445mm)のブロックに分割して、現品に番号を記載します。図 8.1 に溶接手順の一例を示す。2 層目の肉盛溶接を行う場合は、初層で溶接した 1 つ左のブロックを始点として同様の順序で溶接する。

10) Refer to Figure 8.1 for the order of welding the removed parts, and avoid welding adjacent blocks in succession.

除去部の溶接を行う際の順番も図 8.1 を参考にして、隣り合ったブロックを連続で溶接しないようにします。

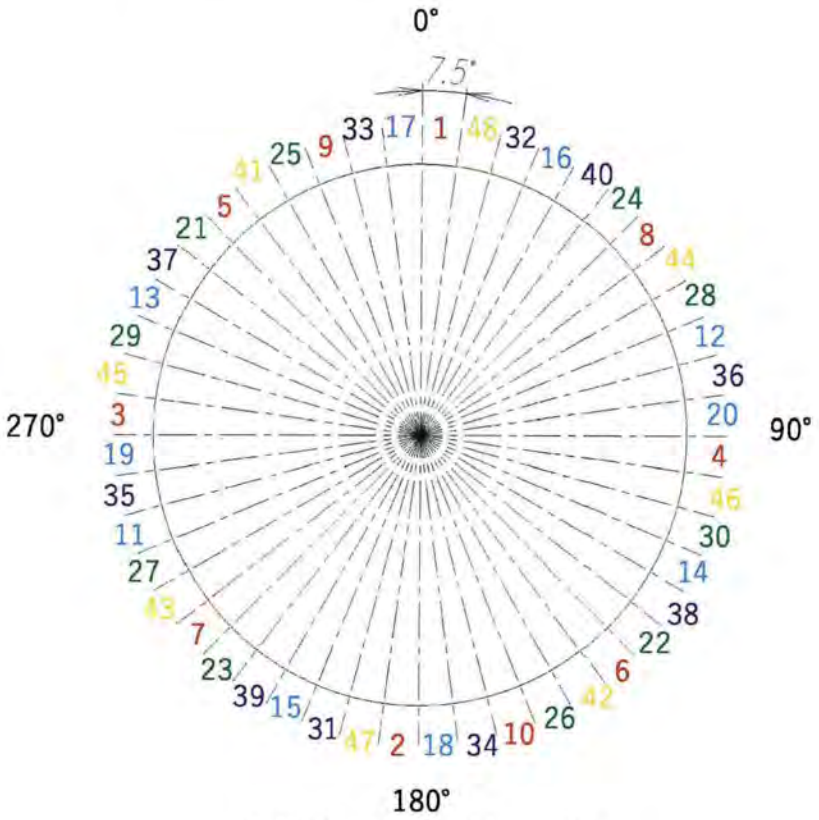


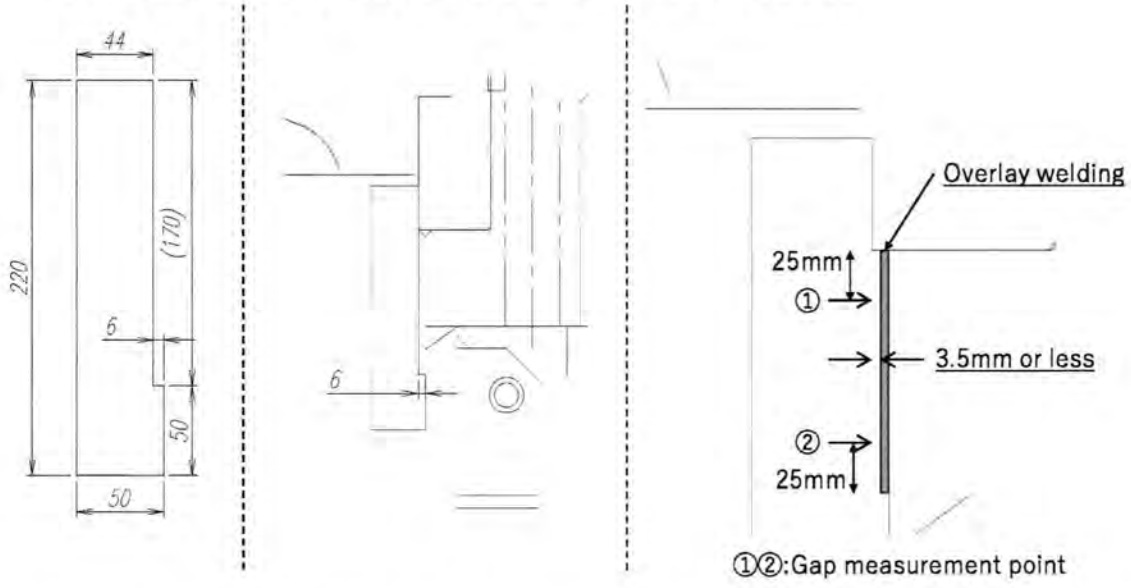

Fig.8.1 Sample of welding order

11) All the welding start and end parts (craters) are ground with a grinder to make them smooth.

溶接のスタート部及びエンド部（クレータ）は全てグラインダで研削し、滑らかにします。

12) The minimum overlay thickness shall be 2.5 mm. Use a gauge to check (Fig.8.2).
最低肉盛厚さは 2.5 mmとする。確認にはゲージを用いる（図 8.2)。

13) If the overall overlay thickness is insufficient after welding the entire circumference with one layer, weld the second layer. When welding the second layer, the starting point should be 50 mm or more away from the joining position of the bead on the first layer (Fig. 8.3).
If the overlay thickness is locally insufficient, overlay welding is performed only at the insufficient parts.
全周を 1 層溶接した後に、肉盛厚さが全体的に不足する場合は 2 層目の溶接を行う。2 層目溶接の際は 1 層目のビードのつなぎ位置から 50 mm以上離れた位置を開始点とする（図 8.3 参照)。
肉盛厚さが局所的に不足する場合は、足りない箇所のみ肉盛溶接を行う。




(a) gauge shape (b) Gauge using image (c) Confirmation of overlay welding thickness

Fig.8.2 Confirmation by gauge

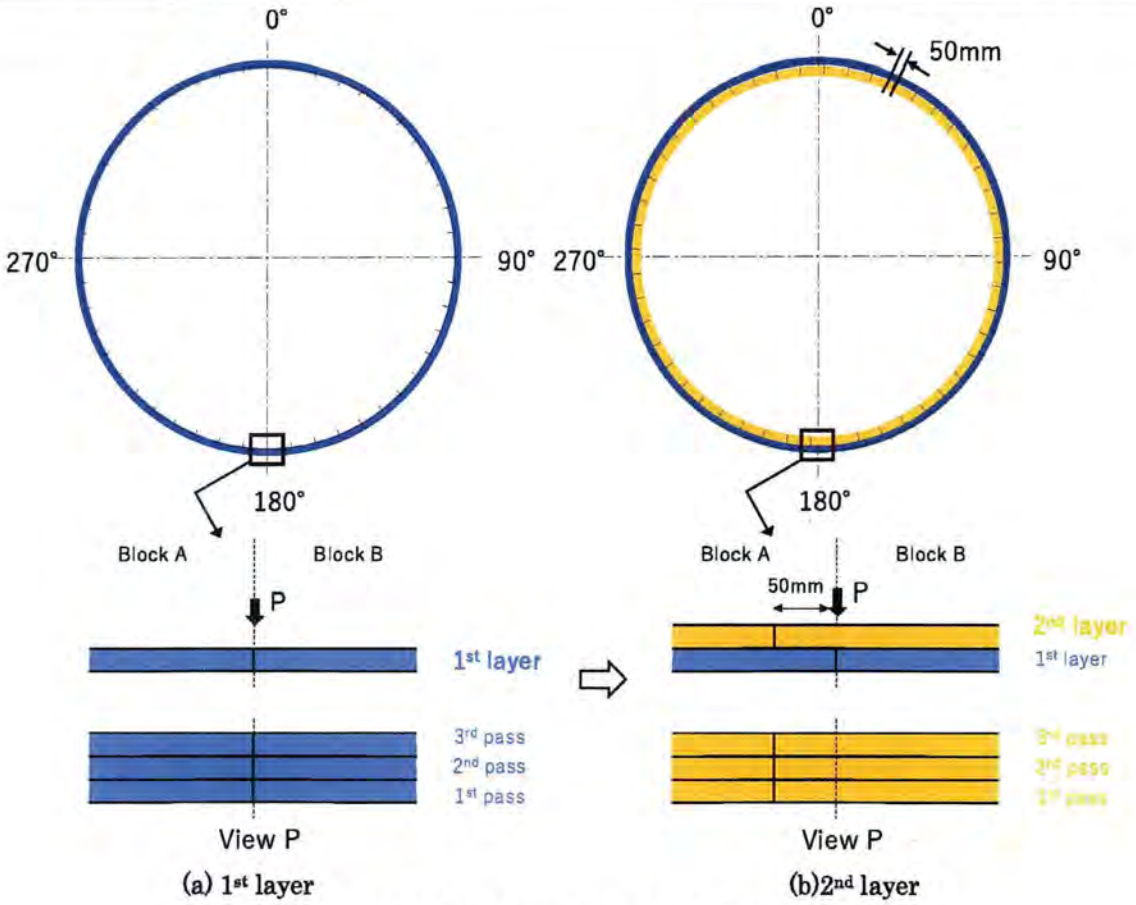



Fig.8.3 Start point shift of each layer

14) Overlay welding should not protrude to the inner diameter than the wearing ring. Remove any that protrude. In particular, check the height of the joints of the beads.
肉盛溶接は Wearing ring よりも内径に出ないようにする。飛び出した分は除去する。特にビードのつなぎ部の高さは確認する。

15) Preheat within WPS before welding. The preheating method is panel heater, gas burner, etc. Measurements are made with a surface thermometer.
溶接前に WPS の範囲内で予熱を行います。予熱方法はパネルヒータ、ガスバーナ等とします。測定は表面温度計で行う。

16) If cooled for dimensional measurement, preheat again before resuming welding.
寸法測定のために冷却した場合は、溶接再開前に再度予熱する。

10. Dimensional measurement during welding
溶接中の寸法測定

1) Measure and record the runner gap during welding. Measurements are taken at the same positions as before welding (Fig. 7.1). The timing of measurement during welding shall be after the welding of the rust-removed part and after the 1st layer welding. Cool down when measuring.

溶接中にもランナギャップの測定を行い、記録します。測定は溶接前と同じ位置で行います（図 7.1）。
溶接中の測定のタイミングは錆の除去部の溶接後、1 層溶接後とします。測定時は冷却します。

2) When welding the rust-removed part, measure and record the runner gap every day before the day shift. Measurements are taken at the same positions as before welding. The measurement is performed in a preheated state, so treat it as a reference measurement. When overlaying two or more layers, measure between layers.
錆除去部の溶接時は昼勤前に毎日ランナギャップを測定し、記録する。測定は同じ位置で行います。
測定は予熱した状態で行うため、参考測定として扱います。2 層以上肉盛溶接する場合は、層間で測定する。

11. Finishing for welding
溶接部の仕上げ

1) The weld bead surface shall not be smooth finished. Remove slag, spatter, and weld burn so that PT can be done.
溶接ビード表面の平滑仕上げは行わない。PT ができるようにスラグ、スパッタ、溶接焼けを除去する。

12. PT where overlay weld area
肉盛溶接部の PT

1) Perform PT after finishing the overlay weld bead.
肉盛溶接ビードの仕上げ後に PT を行う。

2) Acceptance criteria is ASME sec. VIII Appendix 8. Weld repair is not necessary if the PT result is acceptable.
判定基準は ASME sec.Ⅷ Appendix 8 とする。PT 合格であれば溶接補修は不要とする。

3) Weld repair is performed on areas that deviate from the PT judgment, and PT is performed again.
PT の判定に逸脱する箇所は溶接補修を行い、再度 PT も行う。

4) After PT, the dye penetrant ink clean off the surface.
PT 後、表面を綺麗にする。

13. Confirmation of stainless steel overlay welding amount and deformation
ステンレス肉盛溶接量及び変形量の確認

1) In order to confirm the amount of deformation due to welding, the runner gap (A) measured before welding is measured again at the same location and recorded.
溶接による変形量を確認するために、溶接前に測定したランナギャップ（A）を再度同箇所で測定し、記録する。

2) In order to confirm the amount of overlay, the step (B) measured before welding is measured again at the same location and recorded.
肉盛量を確認するために、溶接前に測定した段差（B）を再度同箇所で測定し、記録する。

**TOSHIBA**

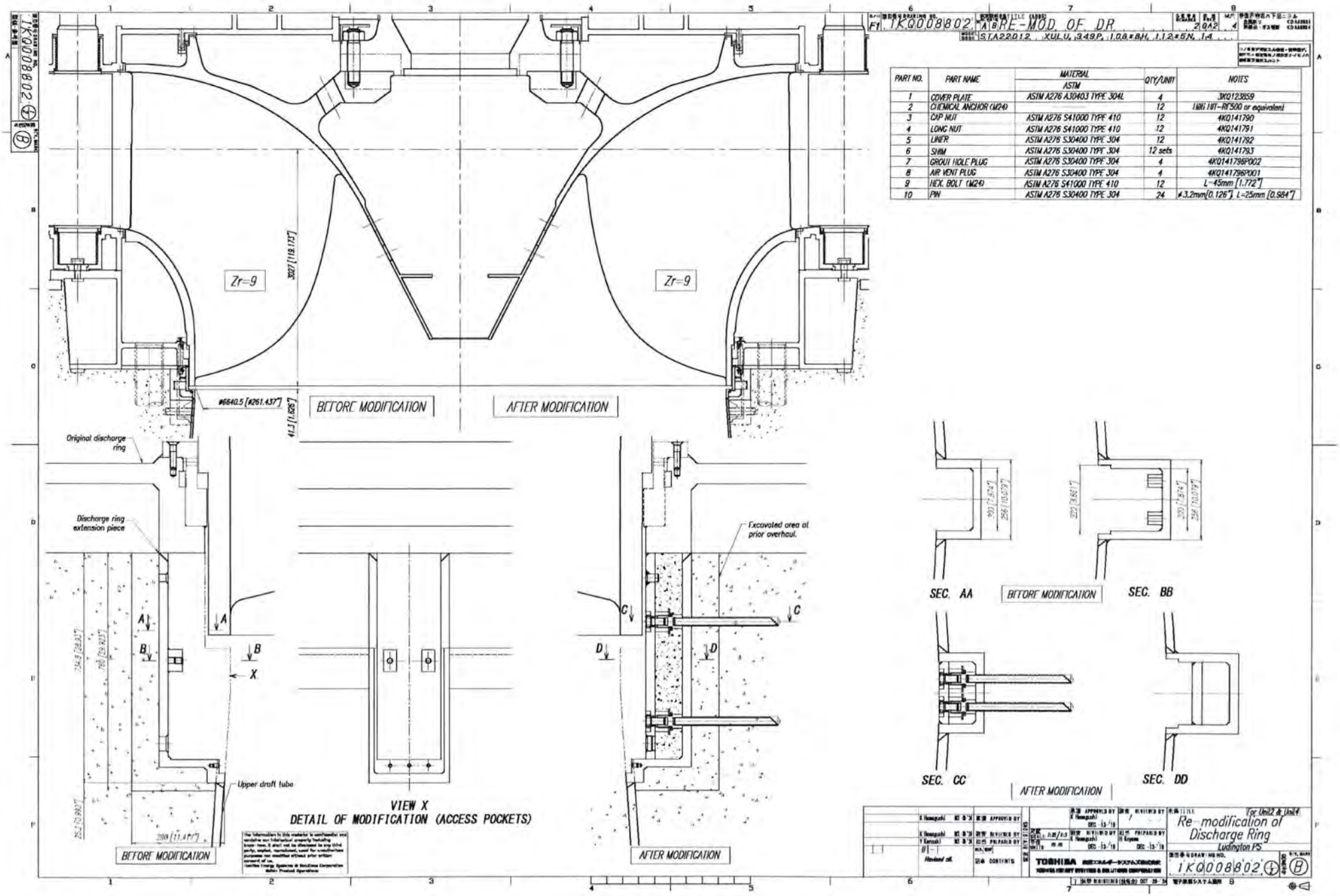
# 経　歴　書

PRC K2022P0327-b

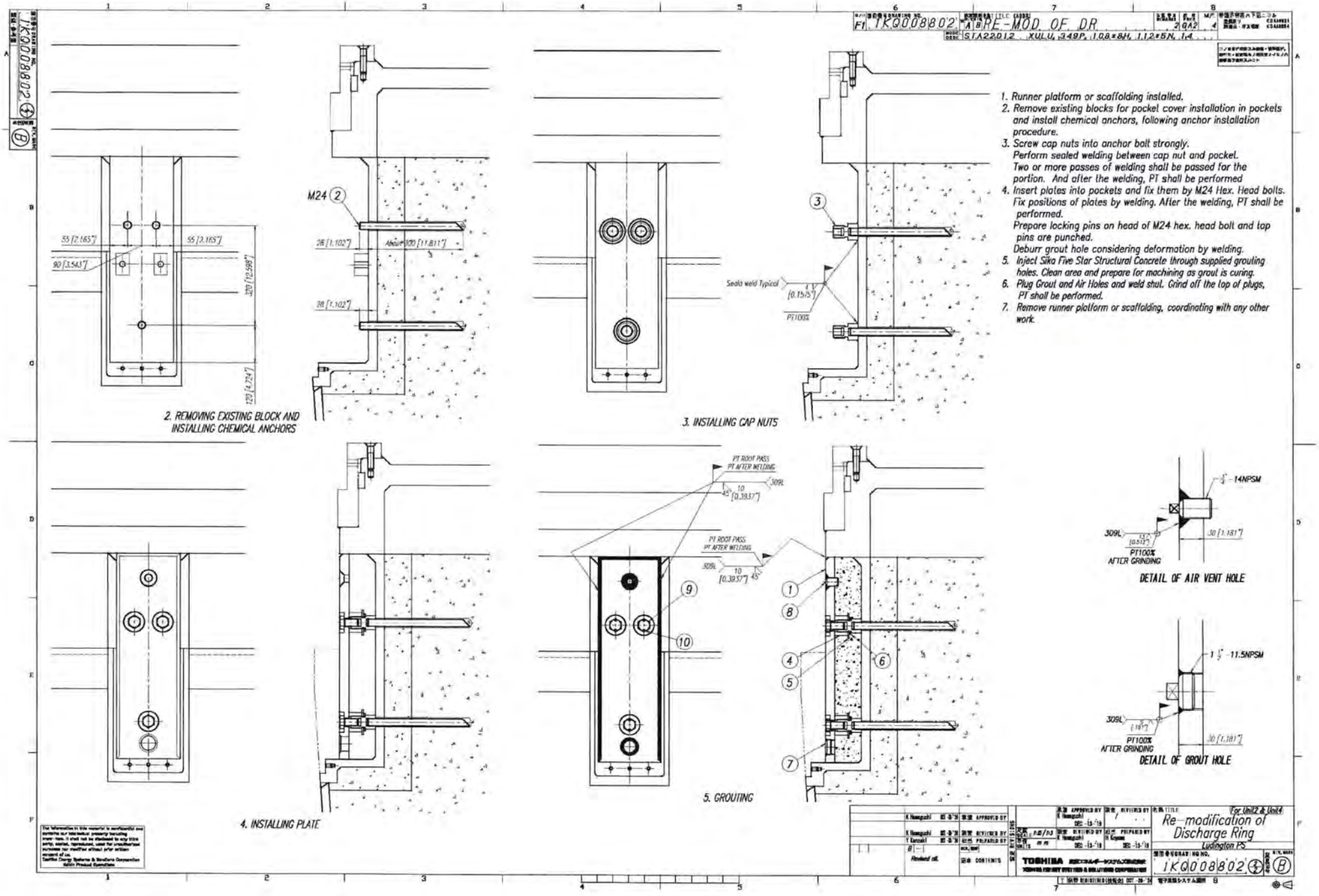
要領書 PROCEDURE



| 変更 REV. | 変更箇所及び内容 PAGE | 変更箇所及び内容 CHANGED PLACE AND CONTENT | 承認 APPROVED | 調査 REVIEWED | 担当 PREPARED |
|---|---|---|---|---|---|
| a | | First edition | Y. Ishizaki Aug.31,2022 | Y. Ishizaki Aug.31,2022 | Y. Nakabayashi Aug.31,2022 |
| b | 6 | Corrections were made to the parts marked with revisions. | See page 1 | See page 1 | See page 1 |




| PART NO. | PART NAME | MATERIAL ASTM | QTY/UNIT | NOTES |
|---|---|---|---|---|
| 1 | COVER PLATE | ASTM A276 A30403 TYPE 304L | 4 | 3KQ123859 |
| 2 | CHEMICAL ANCHOR (M24) | | 12 | Hilti HIT-RE500 or equivalent |
| 3 | CAP NUT | ASTM A276 S41000 TYPE 410 | 12 | 4KQ141790 |
| 4 | LONG NUT | ASTM A276 S41000 TYPE 410 | 12 | 4KQ141791 |
| 5 | LINER | ASTM A276 S30400 TYPE 304 | 12 | 4KQ141792 |
| 6 | SHIM | ASTM A276 S30400 TYPE 304 | 12 sets | 4KQ141793 |
| 7 | GROUT HOLE PLUG | ASTM A276 S30400 TYPE 304 | 4 | 4KQ141796P002 |
| 8 | AIR VENT PLUG | ASTM A276 S30400 TYPE 304 | 4 | 4KQ141796P001 |
| 9 | HEX. BOLT (M24) | ASTM A276 S41000 TYPE 410 | 12 | L=45mm [1.772"] |
| 10 | PIN | ASTM A276 S30400 TYPE 304 | 24 | ø32mm[0.126"], L=25mm [0.984"] |


1. Runner platform or scaffolding installed.
2. Remove existing blocks for pocket cover installation in pockets and install chemical anchors, following anchor installation procedure.
3. Screw cap nuts into anchor bolt strongly. Perform sealed welding between cap nut and pocket. Two or more passes of welding shall be passed for the portion. And after the welding, PT shall be performed
4. Insert plates into pockets and fix them by M24 Hex. Head bolts. Fix positions of plates by welding. After the welding, PT shall be performed.
Prepare locking pins on head of M24 hex. head bolt and top pins are punched.
Deburr grout hole considering deformation by welding.
5. Inject Sika Five Star Structural Concrete through supplied grouting holes. Clean area and prepare for machining as grout is curing.
6. Plug Grout and Air Holes and weld shut. Grind off the top of plugs, PT shall be performed.
7. Remove runner platform or scaffolding, coordinating with any other work.
2. REMOVING EXISTING BLOCK AND INSTALLING CHEMICAL ANCHORS
3. INSTALLING CAP NUTS
4. INSTALLING PLATE
5. GROUTING
DETAIL OF AIR VENT HOLE
DETAIL OF GROUT HOLE
Re-modification of Discharge Ring
Ludington PS
For Unit2 & Unit4
TOSHIBA
IK0008802

www.barnhartcrane.com

BARNHART

# Proposal for Services

October 13, 2022

| Prepared For: Toshiba TAES | Barnhart |
|---|---|
| Contact: Ryan Graham | Contact: Charlie Gorman |
| Email: Ryan.Graham@toshiba.com | Email: Cgorman@barnhartcrane.com |
| Phone: 231-233-7888 | Phone: 779-233-7265 |

**Work Location**: Ludington Pumped Storage Plant, 3525 S Lakeshore Dr, Ludington, MI 49431

## Scope of Services

1. Barnhart engineering to provide a procedure with basic concept drawings showing how Barnhart would lift the head cover and rotating parts on Turbine Generator.

## Assumptions and Clarifications

1. Barnhart Engineering will provide Concept Drawings only, drawings are not for construction.

## Commercial Terms

Engineering Total: **$24,000**

Price Includes:

- Engineering Job walk
- Concept Drawings with Procedure
- Firm Proposal for scope of work

## General Terms and Conditions

1. This offer is valid for 30 days unless otherwise extended in writing and is subject to resource availability at the time of order.
2. Payments shall be due 30 days from issue of invoice with no discounts for early payment.
3. This offer is based upon the conditions of the Barnhart Service Agreement, latest edition unless otherwise agreed in writing prior to mobilization.

Opportunity ID 17-000000

BARNHART

**Accepted and Authorized**

| Customer / Buyer | | Barnhart | |
|---|---|---|---|
| Sign | _____ | Sign | _____ |
| Name | _____ | Name | _____ |
| Title | _____ | Title | _____ |
| Date | _____ | Date | _____ |

**U2/U4 DRE Repairs (Per Unit)**

| | | Activity Duration (Days) | TAES Craft (Hours) |
|---|---|---|---|
| **Jacking Up Rotor and Head Cover** | | | |
| 1380 | Head Cover Disassembly | 21 | 5,400 |
| 1390 | Generator Partial Disassembly | 31 | 5,200 |
| 1400 | Rotor Jacking Up | 10 | 2,400 |
| **Prep for Scaffolding** | | | |
| 1410 | Prep for Scaffolding | 14 | 240 |
| **PT of Discharge Ring Extension** | | | |
| 1420 | PT of Discharge Ring Extension (3rd party) | 1 | |
| **Heating for Weld Repair** | | | |
| 1430 | Heating for Weld Repair (3rd party) | 9 | |
| **Repair Pocket Areas** | | | |
| 1500 | Prepare Pocket Cover Areas for Repairs | 3 | 360 |
| 1505 | Installation of Cap Nuts | 1 | 60 |
| 1510 | Installation of Chemical Anchors | 1 | 30 |
| 1515 | Installation of Plates by Anchor Bolts | 2 | 60 |
| 1520 | Installation of Plates by Welding | 6 | 480 |
| 1525 | Inspection 24 hrs After Welding (3rd party) | 1 | |
| 1530 | Grouting (1st) (3rd party) | 1 | |
| 1535 | Attach Plugs (seal weld) | 1 | 15 |
| 1540 | Grinding Plugs After Welding | 1 | 15 |
| 1545 | Inspection (24 hrs later) (3rd party) | 1 | |
| 1550 | Complete cover seal & plug welding | 6 | 240 |
| 1555 | Inspections (24 hrs. later) | 1 | |
| 1560 | Grouting (2nd) | 1 | |
| 1565 | Attach Plugs (seal welding) | 1 | 15 |
| 1570 | Grinding Plug Areas | 1 | 15 |
| 1575 | Inspections (24 hrs. later) | 1 | |
| **Old Parking Ledge Repair** | | | |
| 1610 | Inspection (WR/DRE Inner Diameter Measurement | 1 | 10 |
| 1620 | Prep for Welding (Fill Space with Round Rod) | 1 | 10 |
| 1630 | Weld where Erosion Greater than 10 mm | 2 | 20 |
| 1640 | Inspection (WR/DRE Inner Diameter Measurement) | 1 | 20 |
| 1650 | Smooth Surface by Hand Grinding | 3 | 40 |
| 1660 | PT Inspection (24 Hours Later) (3rd party) | 1 | |
| 1670 | Overlay Welding 5 mm (2-3 Layers) All Inner Surface of Old Parking Ledge | 9 | 140 |
| 1680 | Hand Grinding All Surfaces | 3 | 60 |
| 1690 | PT Inspection (24 Hours Later) (3rd party) | 1 | |
| 2200 | Repair | 2 | 20 |
| 2210 | PT Inspection (24 Hours Later) (3rd party) | 1 | |
| 2220 | Repair | 1 | 20 |
| 1700 | Inspection (WR/DRE Inner Diameter) | 1 | 10 |
| **Remove Heaters** | | | |
| 1710 | Remove Heaters (3rd party) | 2 | 40 |
| **Remove Scaffolding** | | | |
| 1720 | Remove Scaffolding | 11 | 1,080 |
| **Lowering Unit** | | | |
| 1730 | Lower Rotor | 10 | 120 |
| 1735 | Lower Head Cover | 8 | 120 |
| 1740 | Generator Partial Reassembly | 45 | 12,000 |
| 1750 | Head Cover Reassembly | 53 | 12,000 |


**Overall duration per unit approximately 24 weeks**
**Working 2 shifts 6x10's throughout**